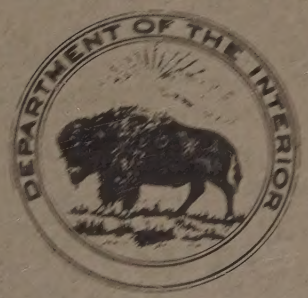
The PROGRESSIVE FISH-CULTURIST

Vol. 11 No. 4



OCTOBER 1949

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

THE PROGRESSIVE FISH-CULTURIST

Issued by

UNITED STATES DEPARTMENT OF THE INTERIOR - - - - - - JULIUS A. KRUG, SECRETARY
FISH AND WILDLIFE SERVICE - - - - - - - - - - - - - - ALBERT M. DAY, DIRECTOR

Printed with the approval of the Bureau of the Budget

Vol. 11, No. 4 October 1949

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(See inside back cover)

The PROGRESSIVE FISH-CULTURIST

News and Views from many Sources on Practical Hatchery Problems

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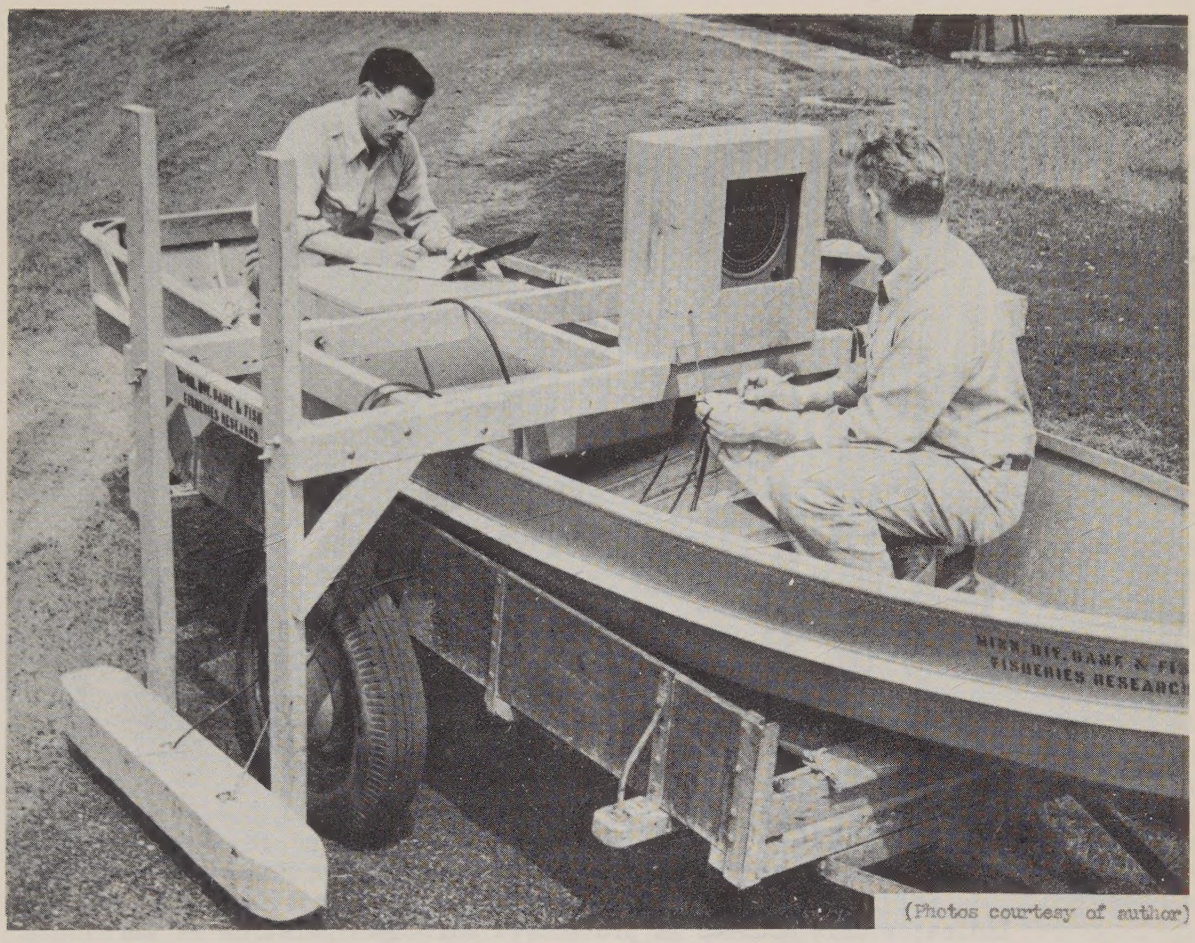
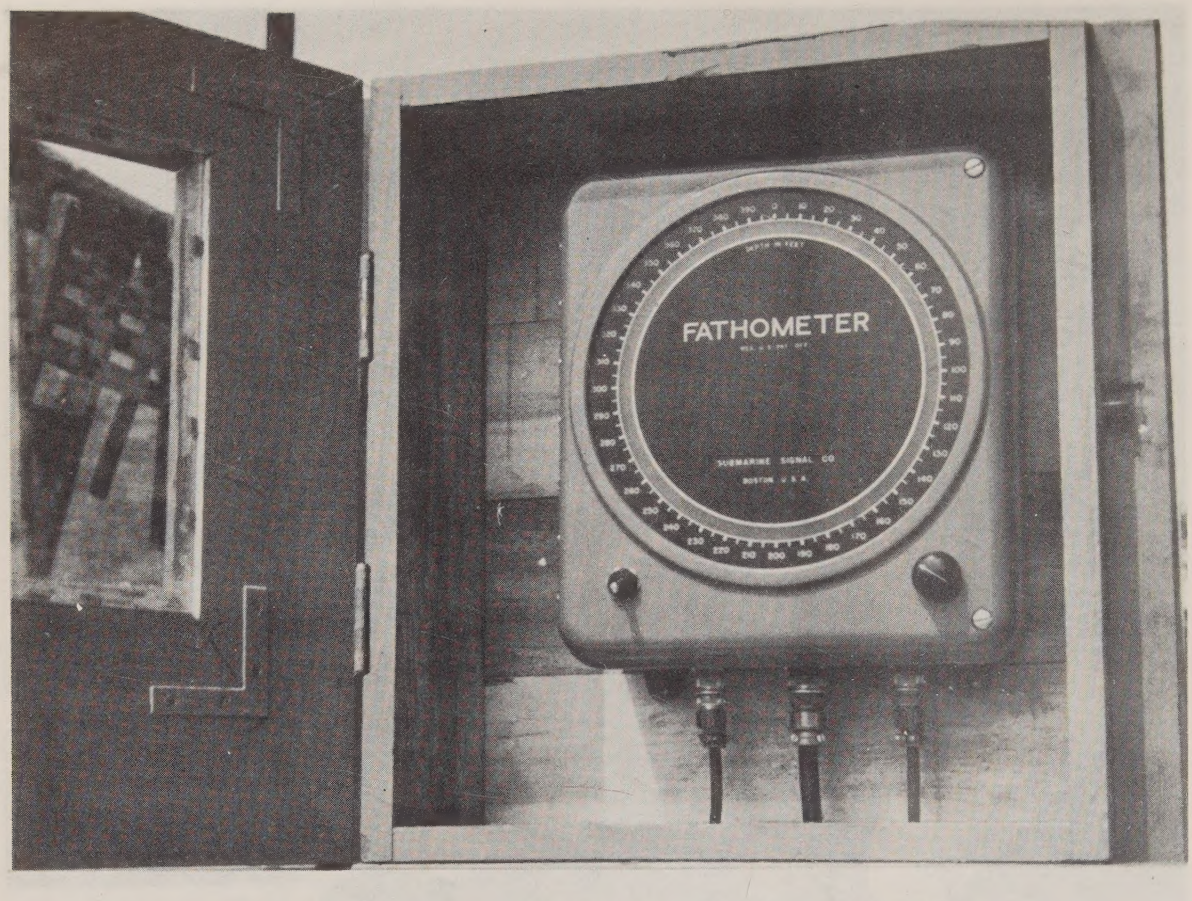


Operating positions of men and equipment during sounding. Oscillators are mounted in underwater "fish" at lower left. Covered box in stern houses battery and power unit and provides a chart table for the man who steers the course.

AN ECHO SOUNDER FOR SMALL BOATS

Charles R. Burrows
Minnesota Department of Conservation
St. Paul, Minnesota

ECHO SOUNDERS have been in use for many years in all seagoing vessels and in many large ships plying inland waters. Echo sounders are standard equipment for all oceanographic work. Their adaptation to inland waters has been slow, however, and there has long been a need for these instruments in limnological investigations. The Minnesota Bureau of Fisheries has recently obtained and converted an echo sounder for use in its lake-survey program, and though this may not be the first instrument so used, its advantages are becoming so obvious that the story



Indicator unit mounted in protective box. Manipulation of the power switch (left) and tuning knob (right) produces red flashes on the scale at the zero point and at the proper depth.

is worth telling.

In the past, sounding operations have been conducted in both summer and winter by means of hand lines. Although satisfactory contour maps can be drawn from hand-line soundings, the work is both arduous and time-consuming, particularly in winter. Now, echo-sounder operations have proved highly successful and a crew of two men can sound a lake of 1,000 or more acres in a few hours if they are careful to cruise only the necessary number of profiles over deep or irregular bottoms.

Several considerations influenced final choice of this equipment. The sounding apparatus must be portable and adjustable to boats of different sizes. In the course of a few weeks of work, the apparatus must be carried in and out of 70 or 80 lakes--some large and requiring large stable boats, and others small and needing only small boats. The apparatus must also be easily assembled and dismounted, and readily handled in transit or in operation by a small crew.

As originally received from the manufacturer, there were three parts to the assembly: an indicator unit to be mounted on the pilothouse bulkhead, registering depths in feet on the dial by means of a flashing red light; a power unit connected with the DC power supply of the vessel; and two oscillators, one transmitting and one receiving, which usually are bolted to the keel of the vessel.

Arrangement of these units has been modified in adapting the instrument to the small boats in use on most Minnesota lakes. Instead of outfitting a special sounding boat, the units are mounted in such a manner that they can be used on any

boat and easily disassembled for transport. The oscillators are mounted in a streamlined wooden "fish," which rides just clear of the boat hull and about 2 feet under the surface. The "fish" is supported by two uprights connected to two crosspieces placed across the gunwales in the manner of a Polynesian outrigger. The indicator unit is enclosed in a weatherproof box provided with a glass window, standing upright and facing forward. The power unit and a storage battery are in a covered box in the stern of the boat.

The assembly dismantles into sections that can be carried singly by one man. The crosspieces have been made long enough to span the beam of any open boat used on inland waters. The point of upright attachment is adjustable so that the "fish" can ride at the prescribed depth regardless of the freeboard. Recent use indicates that the "fish" may have to be hinged to the horizontal crosspieces to facilitate its quick lifting when the boat runs unexpectedly into shoals or rocks.

Under ordinary circumstances only two men are required to operate the unit. One man, seated in the stern, operates the outboard motor and steers the course according to the chart laid before him on the cover of the battery and power unit. The other man sits forward but faces aft and records the depth.

The course is steered between check points (on the beach) which are easily located on the map, and the distance between the points is run at a constant speed. Soundings are recorded at regular intervals by the watch and are identified with the proper leg of the course on the map. Notations are made of the distance offshore at the start and end of each leg. Thus, based upon a given number of soundings taken at regular intervals of time from a vessel moving at a constant speed, the readings represent depths at equal intervals of distance on the map. All that remains to be done in transferring the tabulated data to the map is to divide the map length of a particular leg (minus the distance offshore of the starting and ending points) into a number of equal parts which will correspond to the number of soundings.

Use of compass or of transits is obviously necessary on large lakes where shoreline check points are indistinguishable or are hidden below the horizon. Extra manpower is then needed on walkie-talkie equipment or other signaling equipment.

The first 100 hours of operation under varying conditions, deliberately designed to test the accuracy and ruggedness of the sounder, have proved outstandingly successful. The considerable cost of equipment and modifications has quickly been offset by the savings in personnel time and salary.

In India, a single dusting with a 1-percent mixture or one spraying with a 0.01-percent solution of the commercial weed killer methoxone (2-methyl 4-chlorophenoxyacetic acid) has been reported to be sufficient for complete control of water hyacinth. A 1-percent sprayed solution has been very effective in the control of water weeds such as Lemna, Pistia, and Salvinia.

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hatchery statistics

Fremont, Ohio

THE PROGRESSIVE FISH-CULTURIST
Washington, D. C.

Gentlemen:

Subject: Hatchery Statistics

When I was a kid, my uncle took me along to watch him play golf. When he swatted the ball six times before it rolled into a hole in the ground, he got out a card and marked "4" on it. When I asked if it shouldn't be a "6," he said, "No, you are thinking of school arithmetic. Golf arithmetic is different."

Then once my uncle caught a big bass. My mother had me take it to the meat market to be weighed. The butcher said it weighed 3 pounds and 9 ounces. But the butcher was using school arithmetic. Both my uncle and the Sunday paper said it weighed 6 pounds.

I finally began to realize that there are different kinds of arithmetic.

When we opened our private hatchery, our production wasn't very good. We soon discovered the trouble, and things improved immediately. We had been trying to operate on school arithmetic when we should have been using fishery statistics. Our production improved a lot after we developed a formula. Since other hatchery men might want to improve their production, I am presenting the formula here.

When you take eggs, multiply the number by the factor 0.8. In other words, if you have a million eggs, you multiply by this factor and record the answer, which in this case is 800,000.

Then when the eggs hatch, you multiply the number of young by another factor, 1.5. If you got 500,000 fry, you multiply by this factor and record the result, which is 750,000. In other words, you got nearly a hundred percent hatch, which is very good.

Then when the fish are ready to stock, you multiply the count by still another factor, which is 3.0. If your count is 250,000 fish of stocking size, you multiply by this factor, which gives you 750,000. In other words, all the hatched fish grew up.

One thing bothered us for a while. If all fish grew up, why were there dead ones on the bottom from time to time? Then we watched some insects and a snake shed their skins and discovered the answer. What we thought were dead fish on the bottom were simply the shed skins of fish.

By using fishery statistics instead of school arithmetic, we made a big success out of a hatchery which hadn't been doing so well. You can't tell me that statistics don't pay--I tried them. If your hatchery isn't doing well, maybe you use the wrong formula.

Yours for more and better statistics,

Hatchery Statistician.

EFFECTS OF AN AERIAL APPLICATION OF DDT ON FISH AND FISH-FOOD ORGANISMS IN TWO PENNSYLVANIA WATERSHEDS

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DURING THE last 3 years, great strides have been made in the practical use of DDT for the control of mosquitoes and defoliating forest insects. In widespread control operations, bodies of water are intentionally or unintentionally sprayed. In either condition, the detrimental effects on fish should be ascertained so that steps may be taken to minimize the damage. Studies summarized by Surber (1948) have shown that DDT is toxic to fish, and that the amount of damage is ordinarily proportional to the dosage used and is especially serious in shallow bodies of water. In the field of forest-insect control, great interest centers around a single aerial spraying made at the rate of 1 pound of DDT per acre, as this dosage has proved effective against several devastating defoliators. Past studies of the effects of this dosage on fish and fish-food organisms have been limited to small streams or to 1-mile sections of large streams. Under these conditions damage to fish has been negligible, but 70 to 90 percent of the fish-food organisms have been lost shortly after the spraying. A year later, however, some of the streams contained as great a variety and abundance of insects as before the spraying (Hoffmann and Merkel 1948). Although the results of studying sections of streams have been an aid in evaluating the effects of DDT on fauna, such results cannot be used to forecast what might be expected when large areas encompassing important streams and their tributaries are sprayed within a few days.

Early in 1948 an aerial application of DDT was made on a 52,000-acre area for the control of the gypsy moth, Porthetria dispar (L.). In so large an area it was possible to study the effects of the insecticide on fish and fish-food organisms immediately after the spraying and at later intervals, without having the picture obscured by migration or by immigration of species from nearby untreated areas. Such an approach seems desirable, since operational and ecological factors can be studied in their entirety. The present report is concerned primarily with the effect of DDT on fish. Complete data on the effects on fish-food organisms will not be available until thousands of specimens have been identified. It should be remembered that in spraying large acreages of forest by airplanes, it is impractical to avoid spraying small streams and ponds. This is particularly true when large, fast airplanes are used. Therefore, an appraisal of fish losses likely to occur at different dosage levels of the poison under varying ecological conditions should be made to serve as a guide in future spray work, since losses will of necessity be

weighed against other economic considerations.

DESCRIPTION OF STUDY AREA

The study area is about 11 miles southeast of Wilkes-Barre, Pennsylvania, and includes the eastern half of Bear Creek Township, all of Buck Township in Luzerne County, and most of Lehigh Township in Lackawanna County. The forest is considered to be a red oak-black oak-white oak type. Gray birch, red maple, alder, black cherry, and rhododendron predominate along the margins of the streams.

Studies were made on Bear Creek and Choke Creek, two of the largest streams originating within the area. They are cold-water streams, which in years past are purported to have sustained large trout populations. In recent years, however, the trout populations have been low, owing to deforestation, severe floods, and heavy fishing pressure. Ordinarily the streams flood their banks after hard rains, particularly in the spring; but frequently these streams are exceedingly low in the summer during drought periods. The bottom in riffle areas consists largely of rubble with some gravel and sand, and most of the rubble is covered with either algae or mosses. The streams are permanent and even during their lowest level have a velocity of 1.5 to 4 feet per second in the main riffles. Some parts of the streams are open, whereas others are overhung by forest canopy.

TREATMENT OF STUDY AREA

In general, when the area was sprayed, upper parts of the streams were covered before the lower sections. The maximum effect of the poison on the fauna, therefore, might be expected near the mouths of the streams.

The spray formula consisted of 1 pound of DDT, 1 pint of xylene, and 7 pints of kerosene per gallon, and this was dispersed at the rate of 1 gallon per acre. Most of the 52,000-acre area was sprayed by a C-47 airplane equipped to disperse a load of about 900 gallons of spray in 10 minutes. A small plane, such as an N3N-3, was used to spray around lakes to avoid contaminating them with DDT. The spraying was interrupted because of rainy and windy weather: about 1 month was required to treat the entire area, the coverage of which was completed on June 12.

An ocular measure of spray droplets and the amount of spray deposit was obtained by putting out clean glass plates at 100-foot intervals along streams where detailed studies were made. The presence of oil films on water was noted, particularly on small water holes, which were abundant after heavy rains. Examinations invariably indicated that good spray coverage was obtained. Wind was frequently an important aid in dispersing the spray to places that were covered with dense forest growth. Some spray swaths overlapped, the results being double coverage and mortality of fish. On one occasion, drift from the C-47 formed a rather complete but momentary oil slick on a pond 1 mile from the flight swath. Although several species of sunfish had been feeding there only occasionally, hundreds rose to the surface immediately after the spraying and fed upon affected insects for about 10 minutes. The total amount of DDT present was too small to kill fish.

METHODS OF STUDY

Several days before spraying, weirs made of hardware cloth were installed on two streams to stop fish that might be affected by the spray and washed downstream (figure 1). The screening was kept as clean as possible to reduce the water pressure, which became very great as vegetation and other debris stopped up the meshes of the wire, particularly during periods of high water. Experience has shown that iron pipes make the best posts. They were driven deep into the stream bed and guyed to large boulders or trees to enable the weir to withstand high waters and clogging. The lower edge of the hardware cloth was extended at least 1 foot upstream on the stream bottom and held in place by large flat stones. The use of chicken-wire netting upstream from the weir proved helpful in retaining

the larger debris. The weirs were examined frequently for fish during the first few days after the spraying and then daily for about a month. Specimens were preserved in 10-percent formalin solution.

After it was evident that some fish were being killed by the DDT sprayings, patrols of streams were made daily. Any dying or dead fish along the banks, as well as any unaffected fish, were counted. Lake shores were likewise patrolled daily, and seinings were made to determine the numbers of fish present after the lethal effects of the poison had worn off.

The abundance of stream insects was determined by taking three samples with a square-foot stream sampler at selected stations on the larger streams of the two watersheds before the spraying and at approximately monthly intervals after the spraying. Samples were also taken from check streams in watersheds outside the sprayed area.

EFFECT OF DDT SPRAYINGS ON FISH AND OTHER ANIMALS

Bear Creek

The water in Bear Creek is soft and brownish; the flow is about 8,000 gallons per minute (17.7 cubic feet per second). A weir was erected 4.4 miles downstream from the source of Bear Creek near the head of Antler Lake. The drainage area above the weir included 3.4 miles of Meadow Run, an important tributary.

This area was sprayed on May 26-27, and some small golden shiners were killed immediately. Records of fish mortality are available only through May 29, because during that night high water demolished part of the weir (which was not replaced). The numbers and average length of the 101 dying or dead fish removed from the weir during the first 3 days after the spraying were as follows: 60 golden shiners (Notemigonus crysoleucas), 2.9 inches; 38 common white suckers (Catosomus commersonnii commersonnii), 10.2 inches; 2 northern brown bullheads (Ameiurus nebulosus nebulosus), 2 inches; and 1 chain pickerel (Esox niger), 13 inches. On May 27 the shore for 1 mile upstream

FIGURE 1.--Fish weir erected near mouth of Choke Creek.

from the weir was patrolled in search of dead fish, but none were found. Only a few live fish were seen, and no schools of minnows were seen. The following day a patrol was made for 2 miles upstream and 29 live fish were seen. A patrol below the weir, including Antler Lake, revealed no dead fish. A few live bullheads were seen in the lake, and 6 pickerel (10 to 12 inches) were noted in Bear Creek below the Antler Lake spillway.

Five common white suckers exhibiting DDT tremors were removed from the weir at 7 a.m. on May 28 and isolated in a wire enclosure in a quiet eddy of Bear Creek above the weir to see if they would recover. These fish regained equilibrium by 4 p.m. The resuscitated fish and five additional suckers that also recovered from the effects of DDT were preserved for later examination of their stomach contents. A like number of suckers that had died almost immediately from DDT poisoning were preserved for the same purpose. The examinations showed that nearly all the fish had gorged upon insects killed or affected by DDT. Shortly after the spraying, countless numbers of bottom-dwelling insects drifted downstream. At this time fish were attracted to the bountiful food supply and gorged upon it. Samples of stream insects taken at three stations in this part of Bear Creek within a week after the spraying, when compared with pretreatment numbers and the numbers in a check stream, showed approximate population reductions ranging

from 70 to 90 percent.

A 0.5-mile section of Bear Creek immediately above Antler Lake was examined for fish on August 11. Several 8- to 11-inch white suckers were observed in the same deep hole in which they had been seen before spraying. A few fallfish (Semotilus corporalis) and a few suckers were seen at scattered points along the stream, but no dace or other minnows. The impression was that the stream had become relatively emptied of fish.

On September 14 a survey for live fish was made from the banks on a 0.25-mile length of Bear Creek about 1 mile above Antler Lake. At this time the water was exceptionally low and most of the fish were concentrated in holes. Altogether, 59 common white suckers, 2 brook trout (Salvelinus fontinalis), and 2 chain pickerel were seen. There were obviously more fish in the pools than had been observed earlier. The following day a survey was made on a 0.2-mile length of Meadow Run, which revealed 44 common white suckers and 2 brook trout. There was no evidence of forage minnows in either stream.

The presence of so many fish in such short distances indicated that only a small part of the total fish population of this stream and its tributary, Meadow Run, had been destroyed by the DDT-spray application.

Antler Lake

Antler Lake on Bear Creek is an artificial impoundment that is 16 feet deep at the dam and has a surface area of 15 acres. The bottom is gravelly and has some silt. Many old tree stumps and branches are scattered over the bottom (figure 2).

The woods around this lake were sprayed by means of a small airplane at about 7 o'clock on the morning of June 3, 1948. Although the wind velocity appeared low--the leaves on trees by the lake hardly moved--strong air currents evidently prevailed at higher altitudes. Two swaths were made 300 feet or farther from the eastern shore, and a heavy spray drift was deposited over the entire lake each time. The spray came down like raindrops, but a few minutes afterwards these drops coalesced to form a complete oil slick, at which time several fish surfaced to take insects affected by the DDT spray. Two hours later the slick broke up and, as a result of wind action, became concentrated along the shore, especially in coves. At the 30-foot spillway, where the water velocity was a little more than 2 feet per second, the oil slick continued until about 1 p.m.

Intensive patrolling for dead fish was carried out from June 3 to June 7, and 65 dead fish were noted. Fish mortality began and was greatest the day after the spraying, when the following were collected: 35 pumpkinseed (Lepomis gibbosus), average length 3 inches; 25 common white suckers, 11.2 inches; 4 northern brown bullheads, 5 inches; and 1 chain pickerel, 9 inches. A large number of the dead fish, mostly pumpkinseed, were found on the windward side of the lake, where the water was shallow and the spray scum was heaviest. Undoubtedly, some of the suckers were actually affected in Bear Creek but died in Antler Lake, as some of those taken on June 4 were partly decomposed. Stomach analyses made of 15 of the pumpkinseed indicated that they had been feeding on both terrestrial and aquatic insects. A few of the aquatic insects consumed were lake species, but the intestines of the fish were literally packed with stream insects, particularly May-fly nymphs of the genus Ephemerella, which were affected and washed in from Bear Creek.

A tally of live fish seen near the margins of the lake on June 4 included 29 pumpkinseed and 2 chain pickerel. To obtain an estimate of the numbers of fish left in the lake after the effects of the spray had worn off, several hauls were made on August 11 with a seine 100 feet long, 6 feet deep, of 1/4-inch mesh. Three good hauls completed along a gradually sloping shore produced 8, 11, and 16 fish, mostly pumpkinseed and fallfish, and a few golden shiners and yellow perch (Perca flavescens). Of unusual interest was the fact that fallfish were common in the lake but relatively scarce in Bear Creek above the lake. This condition suggests that the fish migrated into the lake after their food supply in the creek had been decimated. Fallfish apparently

were not killed in the stream or the lake.

Comparison of the number of fish killed shortly after the spraying with the number of live fish observed or taken in seine hauls about 2 months later, suggests that the DDT drift killed small numbers of the total population in Antler Lake.

Observations indicated that a very small percentage of thousands of tadpoles were killed by the spray. Several turtles and 10 pairs of toads mating in the water along one shore appeared unaffected.

A beaver pond of 0.14 acre adjacent to Antler Lake was also sprayed. This pond is littered with snags and has some emergent vegetation at one end. The bottom is muddy, and the depth of water ranges from a few inches to several feet. Spirea grew along the margins of the pond. A number of fish less than 2 inches in length--pumpkinseed, golden shiners, and brown bullheads--were killed by the spray, but 70 green frogs (Rana clamitans) gave no evidence of being affected.

Bear Creek Lake

Bear Creek Lake is an artificial lake comprising 85 acres and is 1.4 miles downstream from Antler Lake at Bear Creek. Although the lake was avoided in the spraying operation, this area probably received a small amount of spray drift. Most of the DDT that reached the lake was probably part of the DDT originally deposited in the upper parts of Bear Creek and on Antler Lake. The numbers, species, and average length of the 216 dead fish collected in Bear Creek Lake between June 4 and June 24 were as follows: 9 chain pickerel, 7.7 inches; 12 yellow perch, 6.7 inches; 9 northern brown bullheads, 7.4 inches; 128 common white suckers, 12.8 inches; 16 golden shiners, 5.0 inches; 20 pumpkinseed, 4.9 inches; and 22 common eastern chubsuckers (Erimyzon oblongus), 12.5 inches. Of the 216 fish, 71 were recorded on June 4, 1 day after Antler Lake had been sprayed. Consequently, it appears that many of the fish that became sick in the waters upstream finally died in Bear Creek Lake. The only species that showed a delayed effect of the spray was the common eastern chubsucker, specimens of which were picked up for the first time on June 17.

FIGURE 2.--Antler Lake.

On June 21 large numbers of frogs, tadpoles, salamanders, pumpkinseed, and thousands of fish fry that appeared healthy, were observed along the shore. Conversations with local fishermen during the summer indicated good catches of catfish and the capture of 7 pickerel that ranged in size from 19 to 24 inches.

Indian Lake

Indian Lake is another artificial lake 4.5 miles east of Bear Creek Lake and in the same drainage area. This lake has a surface area of about 60 acres and a maximum depth of 25 feet (figure 3). It is a fairly open lake; its rugged bottom is dotted with old tree stumps, branches, and other debris. There are several shallow coves on the lake. The fish population consisted of large numbers of sunfish, yellow perch, golden shiners, chain pickerel, and brown bullheads. Most of the pumpkinseed and yellow perch were small.

Spray dribble from the C-47 airplane produced a heavy oil slick on the lake on both June 4 and June 5.

Many affected or dead fish were observed early on the morning of June 5. There were 423 killed by the spray. Mortality was high in the first week, particularly in the first 3 days, but dead fish continued to rise to the surface until 17 days after the spraying (table 1). A large number of dead fish were found in a cove on the windward side of the lake, where the spray was concentrated

TABLE 1.--Numbers and sizes of various fishes killed in Indian Lake after being sprayed with DDT on June 4-5, 1948

Date of examination	Yellow perch	Chain pickerel	Pumpkin-seed	Brown bullhead	Golden shiner	Total
June 5						
Recently killed	8	0	26	1	186	221
Old[1/]	0	0	0	0	0	0
June 6						
Recently killed	5	4	11	1	28	49
Old	0	0	0	0	0	0
June 7						
Recently killed	9	4	20	2	23	58
Old	0	0	0	0	0	0
June 8						
Recently killed	3	5	11	2	14	35
Old	0	0	1	0	7	8
June 9						
Recently killed	0	0	3	1	3	7
Old	4	2	1	0	14	21
June 10						
Recently killed	0	0	0	2	0	2
Old	0	0	2	0	2	4
June 17						
Recently killed	0	1	1	0	1	3
Old	3	0	7	1	0	11
July 1						
Recently killed	0	0	2	0	0	2
Old	0	0	0	0	2	2
Total (all sizes)	32	16	85	10	280	423
Average size (inches)	5.2	8.7	4.3	7.2	5.0	

[1/] These specimens were in various stages of decomposition and obviously had not been killed recently.

over shallow water.

Counts of apparently healthy fish, based upon observations from the shore, recorded 66 on June 5 and 102 on June 9, the latter count being made after the worst effects of the spray were over. To confirm the presence of fish, seine hauls were made on August 12. The results are shown in table 2. Observations around the lake, as well as the seine-haul data collected under conditions that were very adverse because of stumps, indicated that only a small part of the total population of fish in Indian Lake was destroyed by the DDT spray.

Water snakes (Natrix sp.) appeared to be susceptible to the spray. Observers found 6 dead specimens, the size of which ranged from 11 to 24 inches. Comparatively few frogs and salamanders were killed by the spray.

Choke Creek

The mouth of Choke Creek is 2 miles southwest of Thornhurst, Pennsylvania. This stream is 6 miles in length and averages about 20 to 25 feet in width. It is considered a fair trout stream. Some sections of the stream are relatively open; others are well covered by forest canopy (figure 1). The rubble and boulders throughout most of the stream bed are covered with either a heavy layer

of algae or moss.

Several days before the spraying, a weir (figure 1) was installed near the mouth of the stream to catch any fish that might be affected by the DDT spray. The entire Choke Creek watershed was sprayed between June 9 and June 12 by means of a C-47, a DDT-oil solution being dispersed at the rate of 1 pound of DDT per acre. Some fish died within a day after the first spray was applied. By patrolling the stream and visiting the weir frequently, it was possible to obtain a fairly accurate idea of the numbers of fish killed. By far the largest number of fish were recovered in the vicinity of the weir. As shown in table 3, the DDT spray killed many fish during the first 3 weeks after application, but then its toxicity became less.

Of considerable interest are the results of some laboratory experiments run with quart lots of moss removed from the bottom of this stream 18 days after it was sprayed. When the moss was isolated with water from Choke Creek, or with tap water, and 4-inch goldfish (Carassius auratus) were introduced, the fish died

FIGURE 3.--Indian Lake.

TABLE 2.--Number of various kinds of fish seined in Indian Lake, August 12, 1948

Size of fish (inches)	Yellow perch	Chain pickerel	Pumpkin-seed	Golden shiner
First seine haul:				
0-2	0	0	3	0
2-4	0	1	0	0
4-6	1	0	2	0
6-8	2	0	0	1
8-10	1	0	0	0
Second seine haul:				
0-2	0	0	0	0
2-4	0	0	1	0
4-6	1	0	0	1
6-8	0	0	0	0
8-10	0	0	0	0
Third seine haul:				
0-2	0	0	0	0
2-4	0	1	0	0
4-6	3	1	4	2
6-8	4	0	0	1
8-10	0	1	0	0
Fourth seine haul:[1/]				
0-2	0	0	1	0
2-4	0	1	0	0
4-6	5	0	6	0
6-8	1	0	0	0
8-10	0	0	0	0

[1/] Six salamanders were captured in this haul.

TABLE 3.--Number and sizes of various fishes killed in Choke Creek after being sprayed with DDT on June 9-12, 1948

Date of examination	Brook trout	Brown trout	Chain pickerel	Common white sucker	Fallfish	Golden shiner	Total
June 10-16	15	0	1	32	1	0	49
17-23	2	0	1	28	0	2	33
24-30	8	1	1	19	3	3	35
31- July 6	2	0	0	0	0	0	2
July 7-13	0	0	0	6	0	0	6
Total	27	1	3	85	4	5	125
Average size (inches)	3.5	7.0	5.0	5.7	4.5	2.6	

within 8 to 12 hours. All the goldfish exhibited tremors typical of those caused by DDT poisoning. On the other hand, a similar number of goldfish isolated with moss and water from an untreated stream in an adjacent watershed remained healthy. These experiments suggest the cause of the prolonged mortality observed in this creek.

It is believed that the largest number of fish were lost in the lower parts of the stream as a result of the accumulative effect of the spray as it was washed downstream. Four days before the spraying was begun, about 100 small fish were counted in a large pool upstream from the weir. Approximately the same number were observed on June 14, but sometime after that they either succumbed or immigrated to the Lehigh River during flood periods.

On a survey made of Choke Creek (6 miles) on July 8, a week before the weir was removed, 435 fish (mostly white suckers and brook trout) were counted. Blacknose dace (Rhinichthys atratulus) were also abundant. On August 12 a survey of a 0.5-mile section of lower Choke Creek, including the large pool that had had about 100 fish earlier in the season, indicated a scanty population. The same section of the stream and an additional mile upstream were surveyed on September 16, when the sky was overcast and the water level was exceptionally low from drought. One could easily walk the middle of the stream and observe fish as they swam by, and count accurately the main fish population concentrated in pools. Exclusive of thousands of blacknose dace, the species composition of the 171 fish recorded was as follows: 79 common white suckers, 62 brook trout, 18 golden shiners, 11 fallfish, and 1 pickerel. Considering these findings in 1.5 miles of the total 6-mile length of this stream, the loss of fish in Choke Creek due to DDT does not appear alarming.

One insect-sampling station was located near the mouth of the creek, and another about 1 mile upstream. Although much DDT spray must have fallen on and passed over the bottom insects at these stations, the losses within a week after the spraying were not so heavy as had been anticipated: there was an approximate reduction of 70 to 80 percent. Dissections of four of the largest trout that died from DDT poisoning showed that two had last fed primarily upon stream insects and two upon terrestrial insects. Fish (mostly fallfish) seined from the stream on August 12 were in good condition.

Observations on other animals, such as water snakes, frogs, and salamanders, indicated negligible losses.

SUMMARY

The effect of an aerial application of a DDT-oil spray at the rate of 1 pound of DDT per acre on fish and fish-food organisms was studied in two watersheds

within a 52,000-acre area in Pennsylvania.

Several kinds of fish of various sizes were killed by spray or spray drift on ponds, lakes, or streams, particularly where there was double spray coverage.

Within 3 days after the spraying, 70 to 80 percent of the stream insects had been destroyed. That affected insects were fed upon extensively by fish, was substantiated by direct observations and by dissections.

Evidence indicated that fallfish (which normally occurred in a stream) sought a lake habitat, presumably after the insect food had been markedly curtailed in the stream.

DDT spray was carried downstream for a considerable distance, killing both insects and fish. The effects appeared to be accumulative as the DDT was carried downstream. The movement of spray by the wind to one end of Antler Lake and to a cove on the windward side of Indian Lake undoubtedly increased the fish mortality in the shallow-water areas at these points.

Fish populations in shallow ponds were greatly reduced or eliminated in well-sprayed areas.

Counts and observations indicated that relatively few fish were killed in either the lakes or the streams on these two watersheds. It should be remembered, however, that in some locations only spray drift was involved.

Apparently most species of fish are susceptible to DDT poisoning.

In one stream, treated for its entire length at the 1-pound dosage, various fish were killed over a period of 1 month, but the loss was small in comparison with the total population.

Though stream insects were drastically reduced in numbers, the reduction did not seem to affect greatly the condition of fish seined and examined 2 months after the spraying.

The use of large airplanes to disperse DDT at this dosage over large forested areas for the control of noxious insects will unavoidably kill some fish in ponds and streams.

The losses of tadpoles, frogs, and salamanders appeared to be negligible; whereas the mortality of water snakes seemed to be rather high.

ACKNOWLEDGMENT

The writers are indebted to F. C. Craighead, J. M. Corliss, and K. A. Haines for correlating the spray-control program with this research study and for arranging to have M. Mohr, F. W. Graham, and E. P. Merkel assist with some of the field work. The photographs were taken by W. I. May.

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EARTHQUAKE AND GREEN TROUT EGGS

About 11:50 in the morning of April 13, 1949, an earthquake reported to be of 8.14 force struck the area about Puyallup, Washington, and left considerable damage in its wake.

K. D. Hodgeboom, Superintendent of the State Trout Hatchery at Puyallup, reports that when the quake occurred the hatchery had on hand about 600,000 steelhead trout eggs which spawned on 12 different dates. Six of the 12 age groups were well eyed out; so in these groups there appeared only normal losses--other than those that occurred when eggs were splashed out of the troughs by the force of the earthquake. On the other hand, eggs taken between March 28 and April 8 (eggs which were therefore in the green stage) showed varying degrees of damage resulting from shock. Eggs taken approximately 1 hour before the quake occurred were not affected, as the data in the table indicate. The eggs were held in 48° water.

Date eggs spawned	Age	Number eggs spawned	Number eggs lost	Percentage eggs lost
3-28	16 days	23,324	3,956	16.0
3-30	14 days	66,000	27,254	41.0
4-2	11 days	42,500	42,500	100.0
4-7	6 days	65,412	5,036	7.6
4-8	5 days	16,600	532	3.2
4-13	1 hour	170,000	0	0.0

MAYBE WE'VE BEEN OVERLOOKING SOMETHING ---

In some sections of country, when many crops have been gathered from the same plot of ground, it becomes in a degree exhausted, and, whether to improve it for the same or prepare it for another kind of crop, it is usual to overflow it, converting it into a fish pond and stocking it with carps and tench. After three or four years the water is drawn off, the fish taken and sold, and the land cultivated. A few years having elapsed it is again overflowed, but need not again be stocked with fish, as they now appear, as it were, spontaneously. We have the evidence of numerous observers as to this fact, and among others the inhabitants of a commune near Grenoble. They state that there is a little lake on the side of a hill in the commune of Jarrie, not far distant from their town, which is well stocked with carps and tench. Sometimes the lake dries up and the ground is then cultivated with hemp and yields abundantly; and again it is filled with water, and carps and tench appear in great quantities.

---A Complete Treatise on Artificial Fish-Breeding, translated and edited by W. H. Fry. D. Appleton and Co., 1854.

SURVEY OF PROBLEMS IN FISHERY ADMINISTRATION

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IN ORDER to obtain a concept of the kinds and relative magnitudes of the problems which vex fishery administrators, a questionnaire was sent to some 60 such officials in this country and Canada. The period involved was February through April, 1949. Thirty-eight replies were received, including 30 from various States, 2 from Canadian Provinces, 1 from the Territory of Hawaii, and 3 from the U. S. Fish and Wildlife Service.

This report includes a condensed version of the questionnaire and a summary of the replies.

DIGEST OF ANNOTATIONS ON THE VARIOUS QUESTIONS

Efficiency of organization is considered a minor problem. Only one State recognizes a major fault in the structure of its organization: "the placement of responsibility is neither clear nor definite." As for paperwork, three units of the Fish and Wildlife Service and more than half the State agencies questioned mention considerable "red tape," but this is always termed a necessary evil. One State actually needs more reports in order to be "fully aware of the efficiency of each of the hatcheries."

Well-trained personnel is hard to obtain and to hold, according to 60 percent of the replies. This situation is generally due to lack of funds, but in at least four organizations the method of hiring and firing is partly responsible.

Politics is a complex and important problem in most States. Personnel, funds, and policies are controlled, one way or another, by State governments; and there is evidently a difference of opinion among fishery administrators concerning the ideal relationship. Some of the comments, roughly separable into four categories, are interesting and varied:

--Politics and Personnel--

"Uncertainty of tenure does not invite top-qualified men."

"No merit system" of employment and promotion.

--Politics and Policies--

"Due to our county unit system the legislatures have a large voice in our operation in each county."

"Each succeeding legislature sees adverse legislation introduced by special-interest groups. Results are gory."

"Politics are always a threat to long range programs and overall efficiency of operation."

"Political expediency and conservation requirements often conflict."

--Politics and Funds--

The organization is "hampered politically only by difficulty of getting appropriations."

"Some political influence is felt as it concerns funds or programs."

This survey was a class project in a graduate-student seminar on this subject under the direction of Professor Lagler at the University of Michigan.

Miss Virginia Field and Mr. Max Proffitt, with Professor Lagler, compiled most of this report from brief digests prepared by other members of the seminar to show the status of various problems.--The EDITORS.

CONDENSED QUESTIONNAIRE ON PROBLEMS IN FISHERY ADMINISTRATION
AND
SUMMARY OF REPLIES[1/]

Problem	Status of Problem: Major	Minor	None	Failure to check
	(...Percent of Replies....)			
Efficiency of Organization (including red tape)	10	58	24	8
Personnel	34	42	21	3
Politics (including legislative relations)	37	34	26	3
Funds	40	42	13	5
Law Enforcement and the Changing of Laws	26	44	20	10
Fish Culture and Stocking	31	32	26	11
Research	58	21	13	8
Trouble Shooting	34	49	10	7
Publication of Technical Reports	32	26	31	11
Publication of Popular Reports	18	34	37	11
Maintenance of Knowledge of Current Status of the Fisheries	39	41	7	13
Sport vs. Commercial Fisheries	24	48	25	3
Advance Planning	46	38	14	2
Public Relations	61	26	10	3
Pressure Groups	34	58	5	3
Cooperation with Other Agencies, State or Federal, and Integration of Activities	16	34	47	3
Other				
Please indicate which of the above problems is greatest.				

[1/] For each type of problem, the correspondent was asked to give a statement of its nature in his State or administrative unit and to check status.

--Politics in General--

"Bi-partisan commission makes problem of politics minor."

"Politics is a minor problem, even though the organization is under political control."

"This is a major problem, because the organization is controlled by politics."

"Politics is no problem, but congressmen and senators still cause a little trouble by referring their constituents' questions to us for reply." (In this case, the fire is apparently out and the ashes just need a little kicking and stomping.)

Sixty percent of the organizations are short of funds, and legislative control of appropriations is a frequent headache. The Fish and Wildlife Service units are chronic sufferers. Two organizations call funds adequate for justifiable projects but not for salaries. On the other hand, one organization goes on record as follows: "Proposed appropriations likely to strain present organization by imposing too rapid growth."

The fishery administrator's greatest concern in connection with law enforcement and the changing of laws is their effect on the adoption and retention of scientifically sound management programs. For the most part, both laws and enforcement prove fairly satisfactory, and the problem is not too serious. The exceptions to this are contained in the following quotations:

"Too much politics; awful enforcement; could write a book about this."

"Present warden force overworked."

"Laws change too frequently."

"Laws are not based on sound principles."

The greatest problem of agencies that favor intensive stocking is to meet the increased demand for legal-sized fish, a demand brought about by increased fishing pressure. Where curtailment of stocking is advocated, the problem is to convince the public of the soundness of the policy. In general, stocking and fish-cultural programs are hampered by politics and outside pressure groups, insufficient funds, limited facilities, and scarcity and high cost of fish food.

With reference to stumbling blocks in research, one-third of the organizations indicated great need for additional funds and personnel. One agency stated that its long-range research programs are often endangered by outside attacks; another said its sportsmen and legislature expect too much for too little. Several organizations support no research, hence have no problem.

Regarding trouble shooting, there is the problem of how much of this unscheduled work to do, and the problem of funds and personnel with which to do it. Additional ailments are voiced as follows:

"Trouble shooting is a major problem because demands are so unexpected and often upset previously formed plans."

"We usually learn of troubles after the time for action has passed."

Publication of technical reports is considered a minor or nonexistent problem in 80 percent of the organizations. In this group we have those who do not publish and feel no need to publish at present, those who publish little and need no special vehicles for their output, and those with prolific staffs and adequate facilities; this last condition is realized generally in those States that sponsor their own technical periodicals. In contrast, the Fish and Wildlife Service administrators are unanimous in voicing a strong need for facilities and funds. The same need is reflected in the following comments from State agencies:

"... a major problem because sportsmen are generally not sold on the need for these reports."

"Backward--not enough and not comprehensive."

"A major bottleneck to programs in research."

The publication of popular reports is a problem which is rapidly nearing solution as more and more States issue conservation magazines. In addition, increased use is being made of local newspapers. The States that make no provision for popular reports almost unanimously admit a serious

handicap. One administrator (Fish and Wildlife Service) enlarged on his particular problem, as follows:

"We prepare few popular articles. Policy discourages our issuance of such works, since they can be construed as propaganda. One of our major faults exists in our inadequate public relations."

Maintenance of knowledge of current status of fisheries is one of the "big four" problems, according to tallies of the questionnaire reports. Most of the comments may be packed into this brief statement: the organizations are small, and the fisheries vast. As usual, however, we have another viewpoint: "A minor problem easily met by establishment of field biology stations whose men can watch the changes in fisheries day by day."

Although there are many conflicts between sport and commercial fishing interests across the country, the replies indicate that generally the conservation agencies are not deeply involved. Two exceptions to this are:

"We have trouble obtaining money for sport fishery research, but not for commercial projects."

"Rather a serious conflict; the survey does not administer to fisheries, but we are concerned indirectly, for both sides come to us continually with their troubles. Also, we wish to be able to recommend administrative measures equitable to both fisheries."

Advance planning is one of the most troublesome problems facing the administrator. The most common reason is that appropriations are generally granted on a year-to-year basis, and plans must be made accordingly. Also, as brought out in the following comments, the administrator may be powerless for other reasons to formulate long-range plans.

"Cannot depart very far from wishes of sportsmen."

"We set up plans; then someone wants another type of work done."

"It is difficult to plan ahead because of unforeseen demands of trouble shooting."

"The department is suffering from growing pains. Rapid expansion of fish production facilities has handicapped long range planning."

In public relations most of the States have a problem of first-rate importance. Lack of funds and lack of personnel are the principal checks on effective public-relations programs. The situation is summed up by one administrator:

"This is a problem of major importance because biologists usually sell their own programs, and there are not enough biologists to be both public relations men and research men."

Pressure groups are regarded as a nuisance by most administrators. Three agencies, however, reported no problems due to pressure groups; and three more actually considered their pressure groups beneficial, saying:

"We receive sound proposals at public hearings for these groups."

"We achieve excellent relations through these associations."

Pressure groups give "constructive help, usually."

Cooperation with other agencies, State or Federal, and integration of activities is no problem. According to the tone of the comments, all fish men are brothers under their scales. For example:

"Excellent cooperation."

"Complete harmony."

"Very good cooperation."

"Increasingly better."

Listed as other problems in fishery management are "friction among personnel" and "how to find four extra hours in a twenty-four hour day."

Tabulation of the most important problem shows that money is the root of most, if not quite all, evil. In second place is public relations or education, the problem most important to a group of executives who contend logically that this is basic, the real key to all other problems of fishery administration.

VALUE OF THE BOTTOM SAMPLER IN DEMONSTRATING THE EFFECTS OF POLLUTION ON FISH-FOOD ORGANISMS AND FISH IN THE SHENANDOAH RIVER

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IN THE PAST several years legislation and activity directed toward the control and abatement of stream pollution have greatly increased. Numerous States have passed legislation forming water commissions, water-control boards, or other groups or committees to deal with stream pollution within their borders. Some States have formed interstate agencies to deal with activities in a particular river basin. The passage of Public Law 845 greatly increased activities from a national viewpoint.

All these groups have at some time or another been concerned with stream surveys to determine extent or degree of pollution. Many groups have worked on this problem and have come up with varied answers. Some have set arbitrary standards of cleanliness, below which no body of water would be allowed to degrade. Others have classified streams into groups (A, B, C, D, etc.) depending on usage and have set standards of cleanliness to be maintained in each class. Still others have set no standards but have treated each pollution problem separately and have had a board to decide the degree of pollution that would be allowed. Unfortunately, little or no consideration has been given to fish or wildlife in many of these surveys or classifications. For many years sportsmen's groups have been fighting for clean streams, and these groups have been instrumental in causing the enactment of much of the constructive pollution legislation. Yet, when pollution is discussed at various meetings and standards are set for streams, practically nothing is heard about what aquatic life (other than bacteria) is in, or should be maintained in a stream.

For a great many streams there is a wealth of information as to the coliform bacteria count, the biochemical oxygen demand, total solids, color, odor, and other factors; but there is very little information as to what fish or fish-food organisms may be present. True, most of these pollution surveys have been made from the standpoint of public health or for municipal or industrial water supplies--which are, of course, very important. But why not include in these surveys some data as to the effects of pollution on normal aquatic life?

Requirements for water to drink or to operate an industry may be vastly different from the requirements for the maintenance of fish and aquatic life. Water from an open sewer would certainly be unfit to drink but, if not in such excessive quantity as to use all the oxygen in the receiving stream, may even have a beneficial effect (through fertilizer values) on aquatic life. Water suitable for industrial use may have small quantities of some toxic substance which would make that water deadly to aquatic life.

Aquatic life in streams may be depleted generally in four ways: (1) lack of dissolved oxygen, (2) too high or too low hydrogen-ion concentration, (3) smothering

effect of silt or other fine material, (4) the presence of definitely toxic substances. In general, most pollution surveys would demonstrate the first two of these conditions. Dissolved oxygen and pH are standard tests used in pollution surveys, and the requirements of most aquatic animals are known. The third may show up in observations or from turbidity determinations. The fourth condition would become apparent only through elaborate chemical tests and a knowledge of the toxicity of numerous substances to the various aquatic animals.

Simple methods of determining the effects of the third and fourth factors are based upon use of a Surber (1937) square-foot bottom sampler (figure 1) in gravel and rubble, and Ekman or Peterson dredges in mud or silt. Stream bottoms are normally the habitat for numerous aquatic insect larvae and other aquatic animals. These forms may include the larvae of May flies (Ephemerida), stone flies (Plecoptera), dragonflies (Anisoptera), damsel flies (Zygoptera), midge flies and crane flies (Diptera), caddis flies (Trichoptera), dobson flies (Neuroptera), and other aquatic animals such as water beetles (Coleoptera), aquatic earthworms (Oligochaeta), crayfish and shrimp (Crustacea), and snails and clams (Mollusca). These are the principal fish-food organisms. Square-foot bottom samples taken in riffles above and below sources of pollution show immediately the approximate quantity and the types of fish-food organisms present. Without sufficient quantities of these animals, fish soon disappear for lack of food, whether they can survive in the water or not.

Though all of the physical, chemical, and bacteriological determinations normally used in any stream evaluation are quite important, there is frequently a definite lack of biological determination to show the actual impact of pollution on aquatic life in the stream. This has been forcibly pointed out by Beatty (1947). Ellis and Westfall (1946) and Hart, Doudoroff, and Greenbank (1945) established uniform bioassays or toxicity experiments which could be used to show toxicity levels of various chemicals and wastes for fishes. Though such tests

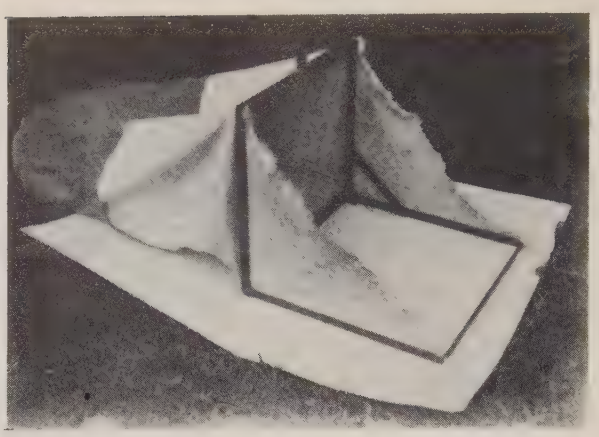


FIGURE 1.--Surber square-foot bottom sampler.

are very useful, there may be great differences between laboratory toxicity tests and actual conditions in streams. Other workers, including Platner (1946), Wiebe (1928), and Ellis (1940), used Peterson dredges and bottom samplers of various kinds to determine the biological impact of pollution.

Methods for the collection and microscopical examination of plankton have been known and used for many years. Many workers, including Lackey (1940), McGauhey (1942), and Purdy (1930), have applied these methods to pollution studies, in which certain types of protozoan plankton and other microscopic organisms were used as indicators of stream pollution.

In a study of pollution of the Coeur D'Alene River, Ellis (1940) called attention to the presence of large numbers of bottom animals, such as caddis-fly larvae and stone-fly and May-fly nymphs, in riffle areas above sources of pollution--and their complete absence below these sources. Surber (1939) used a square-foot bottom sampler of a new, compact design in sampling four eastern smallmouth-bass streams to determine the fish-food organisms present. This work led to the use of this bottom sampler in pollution studies in the Shenandoah River.

PURPOSE OF INVESTIGATIONS

The Shenandoah River was for a long time the favorite fishing ground of numerous residents of northern Virginia and

the eastern panhandle of West Virginia. In fact, this river was so noted as a smallmouth-bass stream that sportsmen were attracted from all over the eastern United States to try their luck at catching the elusive bass. In 1940, a large corporation, the American Viscose Company, began operations at Front Royal, Virginia, on the South Fork of the Shenandoah just above the confluence with the North Fork. Though a clean stream was promised the sportsmen of this section, it was only a short time until fishing in the main Shenandoah had declined considerably. Numerous dead fish were seen in the river during the winter of 1942-43. Sportsmen became alarmed and called upon the Fish and Wildlife Service to determine the condition of the river. Bottom samples taken above and below the Viscose plant showed more than 99 percent decrease in bottom animals 30 miles below the plant, as compared with the number immediately above. This fact was reported to the Virginia Commission of Game and Inland Fisheries in August 1943, but little could be done because of very weak pollution laws. Further fish kills were observed in the winters of 1943-44 and 1944-45, when sport fishing had practically ceased to exist on the main river. About this time, Izaak Walton League chapters were formed in Winchester and Berryville, Virginia, with the clean-up of the Shenandoah River their main objective. These and other nearby chapters sponsored an investigation to determine sources and degree of pollution and its effects on aquatic life in the river: the facts obtained in this study were to be used in making the general public aware of existing conditions. This study was started in June 1947 and was continued throughout the summer. This survey was continued through 1948 by the Fish and Wildlife Service from its Fishery Station at Leetown, West Virginia. Investigations are still under way. This paper is not a complete report of work on the Shenandoah but is undertaken at this time to show certain correlations of numbers and types of bottom animals to pollution, and to show the desirability of using the Surber bottom sampler more widely as a tool in stream pollution surveys.

DESCRIPTION OF RIVER

The Shenandoah River (figure 2) rises in the mountains of northern Virginia, the North Fork in the Allegheny Mountains and the South Fork in the Blue Ridge. Massanutten Mountain separates the two forks. Each fork, fed intermittently by mountain streams and limestone springs, flows a distance of some 150 miles through fertile limestone valleys to Front Royal, Virginia. From the confluence of the forks at Front Royal, the main Shenandoah flows north about 60 miles along the foot of the Blue Ridge Mountains, entering the Potomac River at Harpers Ferry, West Virginia. The lower 20 miles of the river are in West Virginia.

This river is normally a clear, fast-flowing, fertile stream. Extensive riffle areas and limestone ledges serve to make ideal food and cover conditions for fish.

Surber, comparing the Shenandoah River (main stream) with other smallmouth-bass streams in this area (1939), found the growth of bass to be very rapid: the bass reached legal length (10 inches) in 2 to 3 years. Food conditions were reported to be excellent, as there was an abundance of forage fish and bottom animals.

Prior to 1940, the whole Shenandoah River system was considered a mecca for fishermen. Residents of this area claim that as a smallmouth-bass stream it could not be surpassed. Excellent fishing occurred in practically all of the river. The principal species taken were smallmouth bass, largemouth bass, yellowbelly sunfish, channel catfish, carp, suckers, and crappie.

POLLUTION IN THE SHENANDOAH RIVER SYSTEM

Preliminary surveys disclosed no serious sources of pollution (from the fishery standpoint) in the North Fork. Several small towns (Woodstock, Strasburg, and others) discharged raw sewage into the river, but the dilution factor was such that there were no detrimental effects to aquatic life; so the North Fork was not included in this survey.

Three streams--South River, Middle River, and North River--meet just above

FIGURE 2.--The Shenandoah River System.

Port Republic, Virginia, to form the South Fork of the Shenandoah. At Waynesboro, South River receives a serious load of pollution from industries and sewage from the town itself. Fish kills have been reported to the Virginia Game Commission several times. At present, the Virginia Water Control Board is making a study of this part of the river. Owing to this and to the fact that this portion of the river was not considered important for sport fishing, it was not included in this investigation. The remainder of the Shenandoah River system was included (figure 3).

Preliminary bottom samples showed no apparent effect on aquatic life from the sewage of the four towns; so this study was confined primarily to the effect of industrial wastes from the Merck Chemical Company and the American Viscose Corporation plants.

It was suspected that the Viscose effluent contained one or more substances that were deadly to aquatic animals and that this material persisted in the water for a considerable distance downstream. From a study of materials used at the Viscose Corporation plant in making rayon by the Viscose process (Roetman 1944) and a review of the literature concerning toxicity of various substances to aquatic animals (Ellis 1937), several substances --among them, xanthates, hydrogen sulphide, and zinc--were immediately suspected. Xanthates were largely eliminated

FIGURE 3.--Study stations and sources of pollution.

Sources of pollution:

A--The Merck Chemical Company, Elkton, Virginia: manufactures streptomycin, vitamin B_{12}, and other chemicals; empties wastes (nature of which is not definitely known) directly into the South Fork of the Shenandoah River; has facilities for waste treatment.

B--Domestic sewage from the town of Elkton, Virginia: population, 1,500; untreated wastes empty directly into the river.

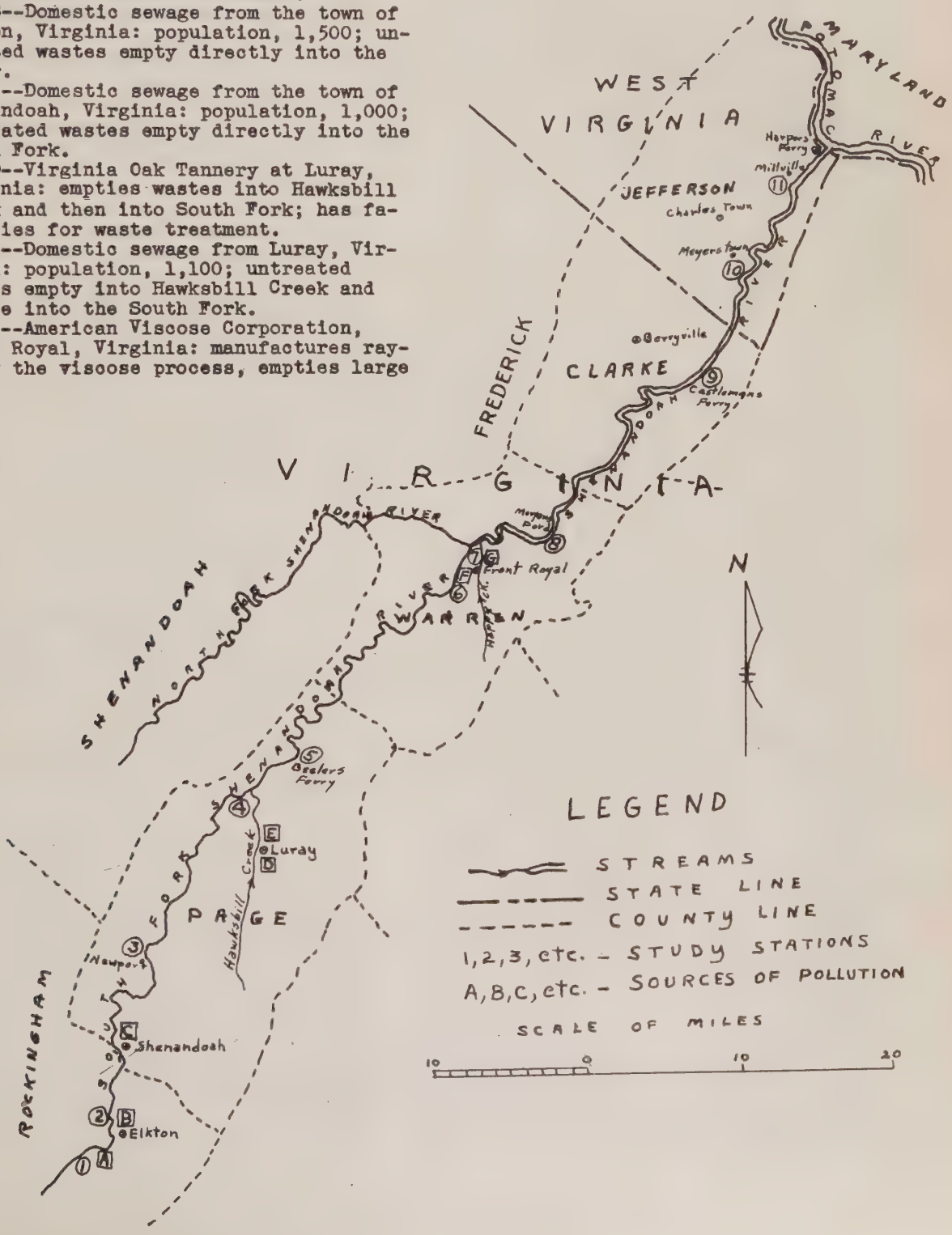
C--Domestic sewage from the town of Shenandoah, Virginia: population, 1,000; untreated wastes empty directly into the South Fork.

D--Virginia Oak Tannery at Luray, Virginia: empties wastes into Hawksbill Creek and then into South Fork; has facilities for waste treatment.

E--Domestic sewage from Luray, Virginia: population, 1,100; untreated wastes empty into Hawksbill Creek and thence into the South Fork.

F--American Viscose Corporation, Front Royal, Virginia: manufactures rayon by the viscose process, empties large quantities of chemical wastes directly into the South Fork, has facilities for treatment.

G--Sewage from Front Royal, Virginia: population, 5,200; untreated wastes empty into Happy Creek and thence into the South Fork.



because of assurance by Viscose Corporation officials that this material could not possibly reach the river and because xanthates could not exist in the effluent under acid conditions. (The effluent was highly acid (pH 2.4) at least at times during the period of major destruction of aquatic animals in the river.) Hydrogen sulphide, though present in toxic quantities in the effluent, was probably eliminated as a result of aeration in the riffle areas of this fast-flowing river. Analysis of the Viscose effluent showed zinc to be present in quantities above 2,000 parts per million. In England several workers with lead and zinc mine pollution had shown zinc in quantities as low as 0.2 parts per million to be lethal to some aquatic animals (Newton 1944). Analysis of the water below the Viscose Corporation showed zinc to be present in quantities considerably above this value: tests revealed the presence of zinc at the rate of 0.4 to 11 parts per million, depending on river flow and other conditions. Zinc was thus indicated as at least one of the major factors contributing to the destruction of aquatic life in the river.

Laboratory toxicity experiments were made with both Viscose effluent and pure zinc sulphate to determine the effects on fish and other aquatic animals. It was determined that the Viscose effluent (in concentrations simulating low water and normal river conditions) was deadly to at least some kinds of aquatic animals, and that zinc itself (in quantities present in the river) was toxic to some aquatic animals, such as bass fry, daphnia, and snails. The results of this work with zinc led Viscose officials to set up their own toxicity work with zinc and to put major emphasis on the elimination of zinc from their effluent.

Since the construction of the Viscose Corporation plant in 1940, that organization has expended considerable amounts of effort and money to work out processes for treatment of waste (Roetman 1944). Until 1948, however, the Viscose effluent was treated only a part of the time, and this treatment was entirely inadequate insofar as the aquatic life in the river was concerned. As a result of the publicity received in connection with this study that showed the river to be virtually devoid of aquatic life, the Viscose Corporation has made further effort to improve the treatment of its effluent and has done additional work in reducing the zinc content of that effluent. Reports (April 6, and December 6, 1948) to the Virginia Water Control Board showed much improvement in treating the effluent. At the present writing (June 1949) considerable progress seems to have been made. Complete treatment (ordered by the Virginia Water Control Board to be in effect by March 1949) has been in effect for some time, and the river appears to be recovering.

SAMPLING STATIONS

Eleven study stations (table 1, figure 3) were established at accessible riffle areas above and below possible sources of pollution. Physical, chemical, and biological determinations were made at each station once each month from June to October 1947, and in June and September 1948. These determinations were made at low-water or normal river stages.

PHYSICAL AND CHEMICAL CONDITIONS

Water temperature, hydrogen-ion concentration, dissolved oxygen, free carbon dioxide, and methyl-orange alkalinity (table 2) were determined by standard methods of water analysis (American Public Health Association 1946). Other physical and chemical data were obtained from the West Virginia Water Commission (table 3).

BIOLOGICAL CONDITIONS

In riffle areas near each station, bottom samples were taken with a square-foot bottom sampler used in the manner described by Davis (1938). Square-foot bottom samples were collected, sieved, and preserved in formalin. The animals were later picked out, identified to order, counted, and weighed (wet weight after draining 45 seconds). (See tables 4 and 5.)

TABLE 1.--Station numbers, approximate location, miles between stations, and stream-flow data

Station No.	Location of stations	Miles from Station 1	Stream flow[1] cubic feet per second 1930-42 average		
			Ave.	Min.	Min. daily
	South Fork, Shenandoah				
1	1 mile above Merck Co., 4 miles south of Elkton, Va.	-	974	32	93
2	3 miles below Merck Co., Elkton, Va.	4	-	-	-
3	25 miles below Merck Co., Newport, Va.	26	-	-	-
4	1 mile above Hawksbill Creek, Shenandoah Lodge, Va.	43	-	70	135
5	5 miles below Hawksbill Creek, Beelers Ferry, Va.	50	-	-	-
6	1 mile above Viscose Co., Front Royal, Va.	86	-	-	-
7	1 mile below Viscose Co., Riverton, Va.	88	1,713	59	103
	Shenandoah River				
8	10 miles below Viscose Co., Morgans Ford	97	-	-	-
9	30 miles below Viscose Co., Castlemans Ferry	119	-	-	-
10	40 miles below Viscose Co., Meyerstown, W. Va.	129	-	-	-
11	50 miles below Viscose Co., Millville, W. Va.	137	2,453	59	194

[1] Stream-flow data from Geological Survey Water Supply Paper 951.

ANALYSIS OF DATA

Physical and chemical conditions in the Shenandoah River (tables 2 and 3) are such that by accepted standards (Ellis 1937) the water would be deemed satisfactory to support nearly all forms of aquatic life. In only a very few instances, and then only for short distances below sources of pollution, were dissolved oxygen and pH values such that a good mixed aquatic fauna could not be maintained. Dissolved oxygen values as low as 3.9 parts per million occurred at Station 2 (3 miles below Merck Company) during low water in the summer of 1947 and averaged 5.9 parts per million for the summer, but at Station 3 (less than 20 miles downstream) dissolved oxygen values averaged 8.4 parts per million and at no time were less than 6 parts per million. At no time was a value for dissolved oxygen at Station 1 (above Merck Company) found below 6 parts per million. This tended to show a definite oxygen demand by Merck Company wastes and indicated that conditions below would be somewhat hazardous to certain organisms requiring high oxygen content of water. Bottom-animal samples (table 4, figure 4) appeared to substantiate this belief. Samples at Station 1 contained an average of 912 bottom animals weighing 6.5 grams, while samples at Station 2 averaged only 108 bottom animals

TABLE 2.--Average, maximum, and minimum values of temperature, dissolved oxygen, pH, free carbon dioxide, and methyl-orange alkalinity, Shenandoah River

Station No.	Water temperature (°F.)			Dissolved oxygen (p.p.m.)			pH			Free carbon dioxide (p.p.m.)			Methyl-orange alkalinity (p.p.m.)
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
	1938 (May 1 to October 31, 5 samples)[1/]												
9	71			9.0			8.2			0.5			116.5
	1947 (June to October, 5 samples)												
1	69	76	54	7.5	10.3	6.1	7.9	8.0	7.9	2	5	0	
2	71	77	56	5.9	8.7	3.9	7.7	7.9	7.5	3	2	6	
3	72	80	56	8.4	10.6	6.0	7.9	8.0	7.7	0	0	0	
5	74	81	64	9.8	11.3	9.1	8.3	8.6	8.0	0	0	0	
6	76	85	64	10.3	12.8	8.1	8.6	9.2	8.2	0	1	0	
7	79	89	66	7.2	9.4	4.4	5.8	7.4	4.4	65	94	10	
8	78	87	64	8.5	9.4	6.3	7.9	8.2	7.2	0	0	0	
9	78	88	62	8.6	9.6	6.0	8.0	7.7	8.2				
10	-	88	-	8.2	-	-	7.9	-	-				
11	-	88	-	7.7	-	-	8.1	-	-				
	1948 (June 23 and September 29, 2 samples)												
		June	Sept.		Sept.	June		June	Sept.		June	Sept.	
1	68	74	61	8.2	9.1	7.4	8.0	8.1	8.0	0	0	0	145
2	68	74	62	7.0	7.9	6.0	8.0	8.0	7.9	1	2	1	140
3	70	78	62	9.1	9.2	9.0	8.4	8.8	8.0	0	0	0	130
5	71	80	63	9.4	10.0	8.8	8.3	8.5	8.2	0	0	0	131
6	75	82	68	10.2	11.0	9.4	8.5	8.7	8.3	0	0	0	121
7	77	85	69	9.2	10.2	8.2	8.0	8.3	7.7	5	10	0	108
8	75	82	68	9.3	9.9	8.8	8.3	8.7	8.0	0	0	0	126
9	72	79	66	7.9	9.1	6.8	8.2	8.2	8.2	0	0	0	114
10	74	81	64	8.6	9.2	8.1	8.3	8.5	8.1	0	0	0	125
11	76	87	66	8.1	9.0	7.3	8.3	8.5	8.0	0	0	0	123

[1/] Surber, E. W. (1938 data).

TABLE 3.--Shenandoah River stream-survey data furnished by West Virginia Water Commission

	Source of sample								
	Point 1[1]			Point 2[2]			Point 3[3]		
Date of sample (1947)	8/29	9/5	9/12	8/29	9/5	9/12	8/29	9/5	9/12
Laboratory number	44	44	44	43	43	43	42	42	42
Water temperature, °F.	80	79	82	82	78	80	80	80	85
Dissolved oxygen,									
p.p.m.	9.7	7.65	9.75	8.25	7.35	7.7	7.25	6.95	7.9
percent saturation	119	93	122	104	89	95	89	85.5	102
Bio-chemical oxygen demand, p.p.m.	0.5	0.7	0.85	0.5	0.75	1.2	0.5	0.6	1.5
Hydrogen-ion concentration (pH)	8.15	8	8.35	8.28	8.45	8.35	8.2	8.2	8.4
Alkalinity[4]									
methyl orange	100	112	116	117	119	115	121	120	111.5
phenolphthalein	-0.5	-0.5	2	Neut.	5	2.5	Neut.	3	1.5
Chlorides, p.p.m.	10.5	10	14	10	11	12	11.5	10.5	11
Hardness, p.p.m.	141	162	171	149	152	156	160	166	170
M.P. No. Coliform organisms X 1000	<0.11	0.026	<0.11	<1.1	0.026	0.11	<1.1	1.5	0.89

[1] Rt. 7, east of Berryville, Virginia. Corresponds to Station 9.
[2] Rt. 9, east of Charles Town, West Virginia. Corresponds to Station 10.
[3] Millville, West Virginia. Corresponds to Station 11.
[4] Negative alkalinity indicates acidity.

TABLE 4.--Average, maximum, and minimum numbers of bottom animals at each station

Station No.	Bottom animals: Number per square foot Ave.	Max.	Min.	Grams per square foot Ave.	Max.	Min.	Pounds per acre Ave.
	1936 (August, 10 samples)						
9	203			10.05			942
	1943 (August, 5 samples)						
6	417			7.45			698
9	4			0.08			7
	1947 (June to October, 5 samples)						
1	912	1,420	340	6.50	10.25	2.18	611
Merck Co.							
2	108	187	78	0.42	1.05	0.18	40
3	528	634	440	4.13	5.01	2.75	390
5	628	866	466	10.55	13.90	4.76	990
6	590	781	325	18.56	23.60	14.45	1,752
Viscose Co.							
7	0	0	0	0	0	0	0
8	70	221	1	0.62	1.50	0.10	59
9	32	92	5	0.12	0.20	0.01	11
10[1]	2			0.05			5
11[2]	19	20	18	0.10	0.10	0.10	10
	1948 (June and September, 2 samples)						
1	1,362	1,469J[3]	1,255S[4]	6.45	7.06J	5.83S	604
2	560	871S	250J	4.07	7.94S	0.20J	381
3	566	675J	458S	1.97	2.39J	1.55S	185
5	714	927S	501J	18.95	20.78J	17.13S	1,776
6	937	1,200S	674J	17.60	27.43S	7.78J	1,649
7	0	0	0	0	0	0	0
8	85	150J	20S	0.29	0.33S	0.25J	27
9	270	367J	172S	0.32	0.42S	0.23J	30
10	187	301J	74S	0.40	0.69J	0.10S	37
11	362	600J	124S	0.64	0.80J	0.48S	60

[1] One sample only.
[2] Two samples only.
[3] J - June.
[4] S - September.

weighing 0.42 gram. Samples at Station 3 (25 miles below Merck Company) averaged 528 bottom animals weighing 4.13 grams. A major portion of the bottom animals at Station 2 consisted of oligochaete worms, leeches, and midgefly larvae (animals having low oxygen requirements); while at Stations 1 and 3 there was an abundance of caddis-fly larvae and May-fly nymphs and other types (table 5) which generally require high oxygen content of the water.

Reports from fishermen also tend to substantiate this conclusion. Though carp (fish having low oxygen requirement) were caught quite often in the vicinity of Station 2, few bass were taken. On the other hand, reports showed bass fishing fair to good near Stations 1 and 3.

The low oxygen conditions existing in the summer of 1947 have evidently been corrected. Samples taken in 1948 (table 2) show dissolved oxygen values well above those expected to support a good mixed aquatic fauna. Bottom animals (table 4) have also shown a remarkable recovery in this section of the river and are now present in numbers and weights similar

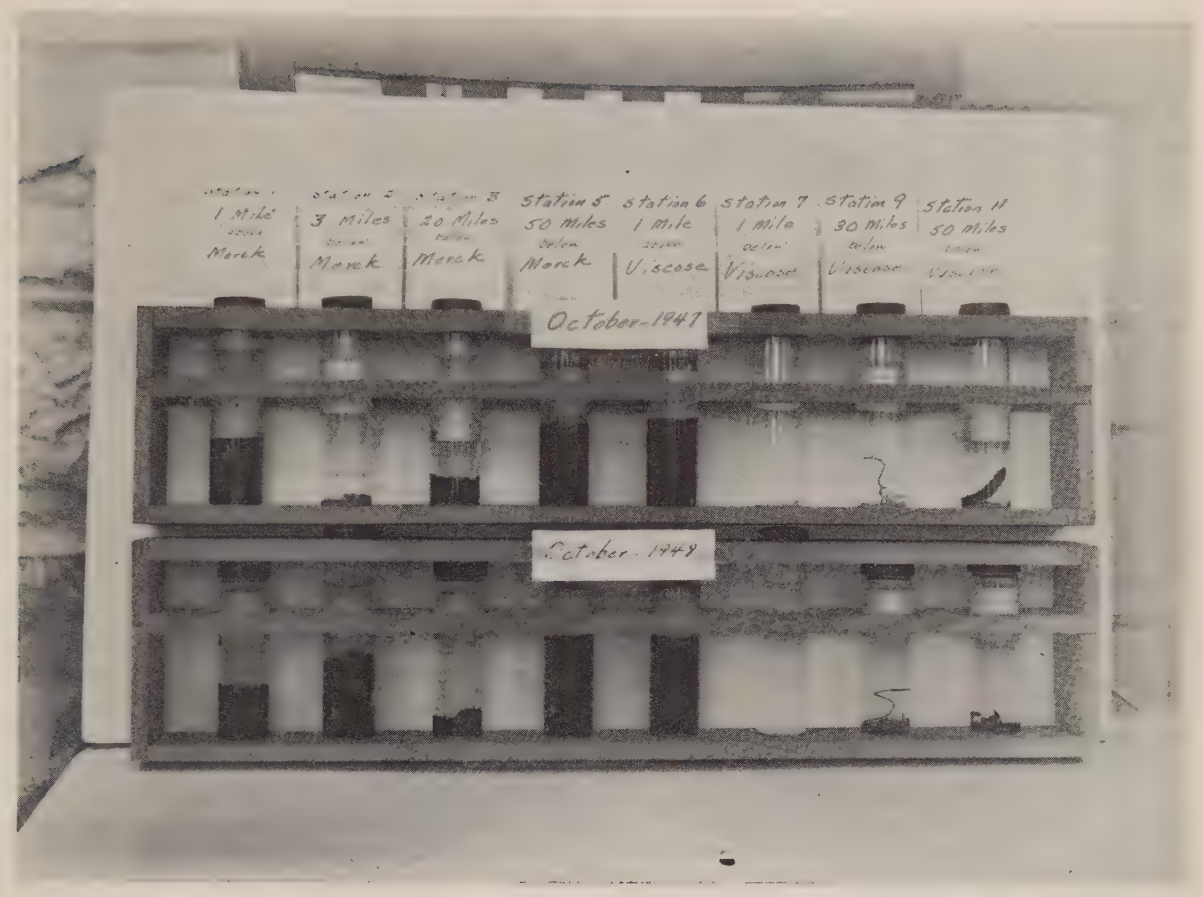

1 Mile below Marek
3 Miles below Marek
20 Miles below Marek
Station 5 50 Miles below Marek
Station 6 1 Mile below Viscose
Station 7 1 Mile below Viscose
Station 9 30 Miles below Viscose
Station 11 50 Miles below
October-1947
October 1947

FIGURE 4.--Bottom animals in square-foot samples.

to what would be expected in unpolluted sections of this stream. Certain of the important types such as May-fly nymphs, however, have not yet appeared (table 5). Caddis-fly larvae and hellgrammites have become very abundant.

From Station 3 to Station 6, the river shows little variation in physical and chemical qualities (table 2). All values are well within the limits that may be expected to support a good aquatic fauna. Bottom animals of types expected were abundant in all riffle areas examined in this section of the river (tables 4 and 5). At the beginning of this study, it was expected that wastes from the tannery and sewage from Luray would have some detrimental effect on the river. Field tests, however, did not substantiate this idea. Chemical and biological conditions appeared as good below this possible source of pollution as above. Consequently, Station 4 was eliminated as a study station. Fish kills in Hawksbill Creek were reported to the Virginia Game Commission late in 1947, but no detrimental effects were shown in the Shenandoah, possibly because of dilution.

This section from Station 3 to Station 6 (approximately 60 miles) is known far and wide as an excellent smallmouth-bass stream. Many excellent catches of bass, as well as sunfish, channel catfish, and other fishes, are taken during the fishing season.

From Station 7 to its mouth (55 miles), the Shenandoah presents an entirely different picture. Although standard physical, chemical, and bacteriological tests (tables 2 and 3) showed nothing seriously wrong, bottom samples taken in the summer of 1947 (table 4) showed this section of the river to be virtually devoid of aquatic life.

It is possible that, while this section (Station 7 to the mouth) is wholly unfit for fishing, values obtained from standard stream surveys (table 3) would place it in a very high category (Class A, West Virginia Water Commission, 1948). Bottom

TABLE 5.--Average number and kinds of bottom animals per square foot

Station No.	Aquatic earthworms	May-fly nymphs	Midgefly larvae	Caddis-fly larvae	Beetle larvae	Hellgrammites	Snails	Misc.	Total
	1937 (June to September, 141 samples)[1]								
9	1.7	46.8	16.4	37.4	14.8	3.8	6.8	4.8	132.5
	1947 (June to October, 5 samples)								
1	1	171	176	458	83	1	4	18	912
2	27	0.4	56	7	3	0.2	21	3	108
3	1	44	56	389	5	2	25	5	528
5	0.5	175	89	217	29	2	104	11	628
6	0.2	137	83	156	73	6	129	5	590
7	0	0	0	0	0	0	0	0	0
8	0	3	59	0.8	6	0.4	0	0.6	70
9	0.6	0	30	0	1	0.6	0	0	32
10	0	0	0.5	0	0	0.5	0	0	1
11	0	0	16	0	2	0	0	1	19
	1948 (June to September, 2 samples)								
1	3.5	196	271	766	87	3	11	24	1,362
2	0	2	349	174	10	1.5	23	1	560
3	0.5	22	192	331	1	2	12	5	566
5	5	269	26	162	26	2.5	186	38	714
6	0.5	473	163	158	41	7.5	77	17	937
7	0	0	0	0	0	0	0	0	0
8	1	1	80	1	2	0	0	0	85
9	4	0	262	1	2	0	0	1	270
10	1	0	185	0	1	0	0	0	187
11	0.5	3	348	8	1	1	0	0	362

[1] Surber, E. W. (1942).

samples (table 4), however, have shown the marked depletion of aquatic life in this stream. At Stations 8, 9, 10, and 11, values for temperature, dissolved oxygen, pH, turbidity, and carbon dioxide (table 2) have consistently remained within limits that may be expected to support a good aquatic fauna. At Station 7, values for dissolved oxygen and pH were below recognized limits for a short time in the summer of 1947 but have since remained within the desired limits.

Bottom samples (tables 4 and 5) have shown that, though bottom animals of most desirable types were abundant at Station 6 (1 mile above Viscose), in no instances were any bottom animals found at Station 7 (1 mile below Viscose). Samples taken at Stations 8, 9, 10, and 11 showed bottom animals to be extremely limited in both number and desirable type (figure 4). In August 1943, examining 5 bottom samples taken at Station 6 and 10 samples taken at Station 9 (table 4), Surber found bottom animals at Station 9 reduced 99 percent in average number and 97 percent in weight. The data from Station 9, as compared with data taken at the same station in 1936 (before pollution), showed a reduction of 98 percent in average number and 99 percent in average weight of bottom animals.

Bottom samples taken in the summer of 1947 showed practically the same conditions existing then as in 1943. Samples in 1948 showed a considerable increase in number and a slight increase in weight. This increase, however, consisted almost entirely of midgefly larvae (Chironomus sp.). Other important fish-food forms, such as hellgrammites, caddis-fly larvae, and May-fly nymphs, have not yet appeared in any degree of abundance.

Though observations in 1947 did not disclose the presence of minnows in the lower river, in 1948 minnows were observed to be present at Stations 8 and 9 and fairly abundant at Stations 10 and 11.

Although fishing in this stream is still extremely limited, reports from fishermen in the summer of 1948 showed that sunfish, channel catfish, and carp were found in the vicinity of Stations 9 and 10. No reports of bass being caught in this section of stream were received, but several small bass (4 to 5 inches) were observed at Station 10.

A fair number of fishermen were observed at Station 11 during the summer of 1948. Though most fishermen considered fishing very poor, quite a few catches of sunfish, channel catfish, and carp--and even a few bass--were reported.

Though some improvement (both chemical and biological) has been made in the lower river, number and types of bottom animals still show a serious state of depletion. No mollusks and very few of the other major fish-food organisms are present (table 5). Until these bottom-animal conditions improve considerably, and until further field studies (including bottom samples) verify such improvement, it cannot be assumed that this section of the river is free of serious pollution.

CONCLUSIONS

1. Pollution surveys ordinarily contain no measure of fish-food organisms or fish in a stream.

2. Standard physical, chemical, and bacteriological methods used in pollution surveys do not necessarily present the true picture with respect to fish and other aquatic animals.

3. The lower Shenandoah River affords an example of a large stream that is relatively free of pollution according to accepted physical, chemical, and bacteriological standards, yet contains virtually no fish or other aquatic animals because of toxic elements from industrial wastes.

4. The Surber bottom sampler is a tool which may be used, in the Shenandoah River and in similar streams, to determine the impact of pollution on fish-food organisms and consequently on fish. By the simple method of using this sampler, the source, degree, and extent of pollution may be determined.

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POND RECORD OF BASS AND BLUEGILL PRODUCTION

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EARLY IN the 1948 season, a large production of bass fingerlings was indicated at the U. S. Fish-Cultural Station at Tishomingo, Oklahoma. This indication and a change in our method of fertilizing bluegill ponds impressed upon us the necessity of keeping accurate records as a basis for plans for the future. We have learned from experience that, to be of value, accurate records must be kept from day to day. Accordingly, we made every effort to record information that would affect production.

It will be noted that each pond has been considered individually, and that only ponds that were used in the production of bass and bluegill are mentioned in this report. Our ponds vary greatly, and by treating each pond as an individual problem we hope to eliminate some of the conditions that affect fish production adversely. Also, the separate record on each pond provides a multiple answer, which could not be attained by a general report covering the entire acreage. Included for each species is a table showing the fertilization, weed control, and production of each pond. Characteristics and management of each pond are discussed in the body of this report.

LARGEMOUTH BLACK BASS

In the 1948 season, 467 bass were used as brooders. These bass averaged 3/4 of a pound per fish, but more than 200 weighed less than 1/2 pound each. Approximately 200 of the adult bass had been carried over from the preceding season; 267 were selected from fingerlings produced in 1947 and transferred from Lake Kiowa in the Wichita Mountains Wildlife Refuge.

Our brood bass are removed from the spawning ponds during the latter part of June or early in July and are then released in holding ponds at the rate of about 300 per acre. These holding ponds are well stocked with small green sunfish to provide live food for the bass. As vegetation in the holding ponds becomes heavy by November, we move the bass and green sunfish to clean ponds at that time. This provides a check on the amount of available food and gives the adult bass an opportunity to feed on the sunfish.

At this station we made every effort to provide an abundant supply of live food for the adult bass. During the period July 1, 1947, to March 15, 1948, 310 pounds of tadpoles and 290 pounds of green sunfish, warmouth bass, and suckers were placed in the bass holding ponds. This represented a daily ration of approximately 0.8 percent of the body weight and was more than sufficient, as 60 pounds of the tadpoles and 48 pounds of scrap fish were in the holding ponds when we moved the bass spawners late in March. The excellent condition of the bass spawners indicated that sufficient food had been available during the holding period. It might be added that all our 3- to 4-ounce female bass were heavy with eggs by March 30--and we have every reason to believe that these fish were less than 1 year old, as they had been selected from the 1947 hatch.

The brood bass were removed from the holding ponds during the period March 26

SODIUM ARSENITE

At top, an area in Pond No. 11 not treated with sodium arsenite.
The two lower pictures show a treated area near the kettle in Pond No. 15 and a complete kill in Pond No. 16.

to 30, and were placed in tanks at the holding house. These fish were immediately graded into two sizes, and the males were separated from the females. We have found that by careful observation and handling 90 percent accuracy can be effected in sexing brood bass just before the spawning season. We had planned to stock the spawning ponds with a ratio of 3 female to 2 male bass, but we finally completed the stocking of small spawners on a 50:50 basis and the larger bass with only a few more females than males. The large brooders were placed in two ponds at a rate of approximately 100 fish per acre and the small brooders were stocked in two ponds at a rate of about 110 per acre on March 31.

Nesting activity was noted by April 5, and seven hatches of bass fry were located April 14. These hatches of fry were found in the ponds which had been stocked with the largest brooders. Usually, large bass (given the same food conditions) will spawn earlier than small bass. By grading the brooders to two sizes, we can concentrate on the collection of fry from the larger fish prior to the collection from the small bass. Also, the use of two sizes of spawners insures against a total egg loss resulting from a late spell of cold weather, and the long period of spawning gives us time for the proper disposition of the fry. Collection of bass fry from the spawning ponds is started when the fry can be caught in a bobbinet seine (8 holes to 1 inch). As April and May are usually very windy in this area, commercial fish oil is used to calm the ponds for observation.

Prior to the 1948 season, we thought that 25,000 bass fry per acre of rearing pond was the maximum that should be used. As a large number of bass fry were available this season, almost all the bass rearing ponds were stocked with 40,000 fry per acre. It will be noted that a number of our ponds show that the harvest of 1½- to 2-inch fingerlings was greater than the original stocking of fry. This was caused by errors in our counting and weighing of the fry. Apparently the water which dripped from the hand net into the small samples of fry that were weighed and counted, caused the errors in total numbers. Another factor that always contributes to error in the number of bass fry being moved is the presence of algae at the time of fry collection. Experience has shown that in warm weather bass fry caught in a net full of algae have a very small chance of survival unless they are released immediately in the rearing pond.

For this reason, numbers of fry caught in nets filled with algae were estimated, and it is apparent that we usually underestimated. This is a fault that appears only when bass fry are abundant.

The bass spawning and rearing ponds were fertilized with barnyard manure before being filled with water, and the rearing ponds were fertilized with manure and inorganic material (12-5-0) as needed during the season. We made no attempt to hold a water bloom in these ponds, and the governing factor in the use of fertilizer materials was the amount of bass food available. No minnows or other forage fish were introduced into these ponds, although some green sunfish entered the ponds through the water supply lines.

Within 30 days after bass fry had been released in a well-fertilized pond, we found that the fish had grown to an average length of 1½ inches. As cannibalism usually develops within 30 to 40 days, we made every effort to remove the fingerling bass from the rearing ponds as soon as possible after the fish had attained this length. The fingerlings were passed through grading boxes to remove the cannibals, then graded again to remove the small fish. The small fingerlings were used for restocking the pond, and the remainder of the lot was distributed to applicants. It will be noted that several of our bass rearing ponds were drained three times during the season, and although the greatest poundage was produced in the ponds that were drained only twice (11 pounds more per acre), 14,800 more fingerlings per acre were distributed from the ponds that were drained the third time. The greatest asset derived from draining a number of bass rearing ponds three times in a season is the reduced time between drainings. This reduces cannibalism, as the fingerlings are graded an additional time and are not in the pond for the period necessary to aggravate the cannibalism. Another advantage gained is the heavier stocking rate that is possible when the pond is to be drained again in a short period, as this permits the longer distribution period which is necessary to move large numbers of surplus fingerlings.

I have always believed that the successful propagation of pondfish requires all of the planning, labor, and fish-cultural ability necessary for the successful propagation of trout. A large part of my time is spent observing the food situation, spawning activities, growth of fingerlings, and other conditions in each pond. These observations

2,4-D

At top, Pond No. 12 was sprayed with 2,4-D on September 17, 1948.
The two lower pictures show the appearance of the vegetation on November 17, 1948.

must be made frequently to prevent the depletion of food organisms or the overpopulation of fingerlings, and to check adverse conditions at the earliest possible time. Also, the care and handling of brood fish will be reflected in the production of eggs.

Several factors have direct bearing upon the production of bass fingerlings. I consider the most important among these to be the care and feeding of brood fish, attention to rearing ponds to avoid depletion of food, and the grading of fingerlings. In the 1948 season this station produced more than 800,000 fingerling bass (their weight, approximately 4,600 pounds), and we know that close attention to those three factors was very important in this production. As the care of brooders and the attention to ponds are discussed in detail, we want to stress the importance that is given to the grading of fingerling bass at this station. Fish-culturists familiar with the cannibalistic habits of bass know that grading is necessary if a large production is expected. Grading involves draining the ponds, and every drainage means additional work, with the result that the proper grading of fingerling bass is often neglected. A check of the tables and of the information in this report will show that grading greatly increases the production. Pond No. 22, for example, showed excessive cannibalism in less than a month after being stocked with fry. If the draining of this pond had been delayed until September, a maximum recovery of 10,000 fingerlings could have been expected. The fish would have been large, but the poundage would have been reduced as the fingerlings outgrew the desire and ability to feed on small insects, so that the large fingerlings would have fed on other fingerlings and the production of small insects would have been wasted. The table shows that 57,000 fingerling bass, weighing 754 pounds, were distributed from this pond even though it was handicapped by excessive seepage. Another example is Pond No. 10, which was stocked on June 17 for the second time. Twenty-two days later the pond was drained again, as we knew that the fingerlings had used the available food. The recovery showed a gain of 113 pounds in the lot for the 22 days. This gain was possible because the pond was stocked with graded fish and because the vegetation kill from the previous draining provided a great amount of food. These are outstanding examples, but the production for the entire pond area showed that repeated draining produced a greater amount of food by killing heavy growths of vegetation, and that the grading of fingerlings reduced loss from cannibalism.

It will be noted that we use a great amount of manure for fertilizer at this station. We find that a greater number of daphnia and related insects can be produced by combining the use of organic and inorganic fertilizer in ponds that have excessive seepage. We try to produce a good culture of daphnia in the spawning ponds before or soon after the introduction of adults, and we try to secure a good culture of daphnia in rearing ponds before we introduce the fry. As time is limited during the second and third stocking of rearing ponds, the culture of insects usually appears about a week after the graded fingerlings are introduced.

We believe that a heavy growth of submerged vegetation is not detrimental to the production of bass fingerlings, provided that the pond can be drained once or twice during the growing season. Vegetation piles are never removed from the ponds, as we find that a certain amount of fertilization is carried to the next season.

Table 1 summarizes the information gathered and recorded for each of the bass spawning and rearing ponds during the 1948 season.

The following paragraphs contain descriptions of individual bass ponds and information regarding the management of each.

Pond No. 1. Approximately one-fourth of the pond area is shallow and covered with spikerush (four-square). The north and west sides of the pond parallel the supply canal, and seepage from the canal maintains the water level after the pond has been filled.

The application of manure produced a good bloom early in the spawning period, and a very large crop of daphnia remained

TABLE 1.--Bass spawning and rearing ponds--1948

Pond No.	Acres	Depth	Water flow 1/ g.p.m.	Fertilizer applied					Weed control				Fish stocked					Fish removed				Production per acre	
				Date	U.2/ lb.	S.3/ lb.	Cow lb.	Goat lb.	Date	S.A.4/ p.p.m.	2,4-D 0.1%	Pond filled	Date	Number (Estimate)	Size	Weight lb.	Date	Number	Size	Weight lb.	Number	Weight lb.
1 5/	0.75	6 in. - 5 ft.	(6/)	3/22	-	-	-	4,000	8/18	-	(7/)	3/26	3/21-4/6	84	small adult	-	4/20-21	129,600	fry	3½	-	-
									9/17	-	(7/)	-	-	-	-	-	5/1-12	50,000	fry	2	239,500	7
																	7/2	11,990	2	110	15,900	147
												7/20	7/23	250	adult	-	10/7	250	adult	-	-	-
2 5/	1.32	2-4 ft.	6	3/23	-	-	-	6,000	8/6	10	-	3/26	3/31	115	adult	-	4/20-21	168,600	fry	8	-	-
									8/23	10	-	-	-	-	-	-	5/1-12	65,500	fry	2	177,300	7½
									9/29	12	-	-	-	-	-	-	6/9	55,000	1½	140	41,700	106
				(Remainder of season shown on bluegill production)																			
4	0.89	2-6 ft.	2	4/15-30	25	22	6,000	-	-	-	-	5/1	5/4	35,500	fry	-	6/7	32,100	2	126	-	-
				5/3-17	50	44	-	-	-	-	-	6/15	6/17	7,400	1½	18½	9/10	6,280	4	157	34,800	297
				6/18	25	22	-	-	-	-	-	10/5	10/7	450	adult	-	12/7	450	adult	-	-	-
				7/28	-	-	2,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
				8/13	25	22	-	-	-	-	-	12/10	12/14	176	adult	bluegill							
5	1.06	6 in. - 4 ft.	8	3/25	-	-	-	2,000	8/18	-	(7/)	4/6	4/20	42,000	fry	-	7/14	20,000	2-7	130	-	-
				4/6-8	30	27	2,000	-	9/17	-	(7/)	-	-	-	-	-	-	-	-	-	-	-
				4/22	30	27	-	-	9/29	12	-	7/20	7/23	6,000	2	30	12/2	4,000	4	100	17,000	189
5½ 5/	1.01	2-4 ft.	8	3/22	-	-	4,000	-	8/18	-	(7/)	3/26	3/31	109	small adult	-	4/20-26	156,600	fry	5½	154,500	5½
									9/17	-	(7/)	-	4/6	-	-	-	6/25	16,000	2	100	15,800	98
												6/24	6/28	300	adult	-	10/7	286	adult	-	-	-
6 5/	1.67	6 in. - 6 ft.	10	3/24	-	-	-	6,000	8/18	-	(7/)	3/26	3/31	159	adult	-	4/20-30	244,000	fry	8½	146,100	5
				7/28	-	-	2,000	-	9/17	-	(7/)	-	-	-	-	-	6/25	36,500	1½	113	-	-
				8/2	-	-	2,000	-	-	-	-	6/28	6/29	13,000	1½	29	9/14	10,350	3	138	20,300	133
8	2.14	6 in. - 4 ft.	18	4/15-22	110	108	8,000	-	9/29	12	-	4/15	4/21-27	83,200	fry	-	5/19	90,000	1½	180	-	-
				5/20-28	55	54	6,000	-	-	-	-	5/26	5/26-29	40,000	1	52	7/22	30,000	2-3	175	-	-
				6/7	55	54	-	-	-	-	-	7/23	7/26	15,400	2	76	10/28	11,520	3	192	35,600	196
				8/13	55	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	2.98	6 in. - 5 ft.	16	3/26	-	-	-	2,000	8/18	-	(7/)	4/6	4/21-30	120,000	fry	-	6/21	99,000	2	445	-	-
				4/5-22	170	150	5,000	5,000	9/7	5	-	6/28	6/29	23,500	2	84	11/23	10,064	3	148	28,700	171
				5/17	85	75	-	-	9/17	-	(7/)	-	-	-	-	-	-	-	-	-	-	-
10	2.25	1-4 ft.	31	4/1-22	128	112	10,000	-	8/18	-	(7/)	4/6	4/20-21	90,000	fry	-	6/2	112,500	1½	225	-	-
				6/7-7/15	192	168	-	-	9/7	7½	-	6/17	6/17	23,260	1½	70	7/9	20,400	2-3	183	-	-
				8/3-23	128	112	1,000	-	9/17	-	(7/)	7/16	7/17	17,000	1½	44	10/11	13,000	3	192	47,000	216
11	2.25	1 in. - 4 ft.	30	3/26-4/22	128	112	2,000	8,000	9/7	7½	-	4/6	4/20	84,000	fry	-	5/25	92,600	1½	186	-	-
				5/28	64	56	-	-	9/17	-	(7/)	5/28	5/29	40,000	1	50	7/18	33,000	2-3	142	-	-
				6/2-7	64	56	-	4,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
				8/4	-	-	-	2,000	-	-	-	7/22	7/22	16,000	2	50	11/26	4,000	3	55	32,700	126
15	3.81	0-6 ft.	20	3/26-4/22	108	95	9,000	7,000	8/18	-	(7/)	4/6	4/26	155,000	fry	-	6/15	186,000	1½-3	590	-	-
				5/3-17	216	190	-	-	9/7	5	-	6/17	6/17	32,000	1½	72½	11/16	15,900	4	318	44,600	219
				6/29	108	95	-	-	9/17	-	(7/)	-	-	-	-	-	-	-	-	-	-	-
				8/13	108	95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	1.33	0-4 ft.	30	3/26-4/22	76	66	6,000	-	9/17	-	(7/)	4/6	4/20	54,000	fry	-	5/28	90,400	1¼	122	-	-
				5/6-28	38	33	2,000	2,000	-	-	-	5/30	5/30	21,600	1	27	7/9	16,000	2-3	100	-	-
				6/7-29	76	66	-	2,000	-	-	-	7/15	7/17	8,500	2	31	9/1	5,465	3	84	61,500	186
				8/4-13	38	33	-	2,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	4.50	6 in. - 7 ft.	800	4/9-22	128	112	-	18,000	-	-	-	5/10	5/12	150,000	fry	-	6/5	66,500	2-3	363	-	-
				5/3-17	256	224	2,000	-	-	-	-	6/15	6/15	35,000	1½	85	10/6	26,300	3	476	12,800	168
				6/16	128	112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
				7/26	-	-	-	8,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1/ Water flow necessary to maintain water level.
2/ Uramon, 42% nitrogen.
3/ Superphosphate, 20%.
4/ Sodium arsenite. Information on treatment shown under pond description. (See Fishery Leaflet 10.)
5/ Bass spawning pond.
6/ Seepage from canal.
7/ 2,4-D weed killer applied to spikerush in water solution (power spray), apparently good kill. (See Fishery Leaflet 217.)

in the pond for 7 weeks even though we removed many for use in other ponds. Vegetation (pondweed and chara) became very heavy by May 1. This probably affected late spawning and protected the fingerling bass from the adults. Fingerlings were fairly even in size but not fat.

This pond was used for spawning, as it is small and has shallow areas for collecting the fry. Only the fry and first crop of fingerlings were produced, as adult bass were held in the pond after removal of the fingerlings.

Pond No. 2. This well-constructed pond borders on a raceway. The pond contains only a small amount of emergent vegetation at the edges.

The application of manure produced many daphnia and related water bugs during the period of bass fry and fingerling production. Water bloom appeared early; algae appeared after 2 weeks. By the end of the fry-collection period, vegetation (pondweed, chara, and sago) had become very heavy, protecting the small bass from the adults but making fry collection difficult. Sodium-arsenite treatments on a 100-foot triangular area near the kettle had very little effect on the vegetation.

First collection--Fingerling bass were not fat, although very even in size when the pond was drained.

Second collection--As this pond was stocked with bluegills on June 21, additional information will be found in the section on bluegills.

Pond No. 4. Although deeper than necessary at the kettle end, this pond is well constructed. A swamp area lies on the east side. As the pond collects seepage from the supply raceway, only a small flow is necessary to maintain the water level. There is a small amount of emergent vegetation in the northwest corner.

Heavy fertilization produced good water bloom during the entire period. Through most of the season, vegetation (pondweed) was very light and scattered; it was only moderate in the last part of the season.

First collection--Fingerlings were fat, and only a moderate amount of cannibalism occurred.

Second collection--Fingerlings were in good condition, even in size. They showed very little evidence of cannibalism.

Pond No. 5. This pond bottom was never completed. Approximately one-third of the bottom is very shallow and covered with emergent vegetation (spikerush). Though the supply raceway is on the west side, there is very little seepage.

Heavy fertilization early in the season produced a fair water bloom which faded when the aquatic plants started growing. Sago was very abundant in the pond area not covered with spikerush. Sodium arsenite, applied to a 120- by 60-foot plot at the kettle, had no effect. Apparently the treatment was made too late in the season.

First collection--Draining was delayed too long. Fingerlings showed a large amount of cannibalism--130 7-inch fingerlings were taken with 2-inch fish--and the smaller fish showed poor growth.

Second collection--Fingerlings were fat and even in size. Apparently the heavy growth of aquatic plants protected the fingerlings from duck predators in November.

Pond No. 5½. Pond No. 5½ is encircled by other ponds. There is very little seepage from this well-constructed pond. A very small amount of emergent vegetation occurs near the shore line.

The application of fertilizer failed to produce the quantity of food that was produced in other spawning ponds, although a good water bloom appeared early in the season. Daphnia were abundant early in the season, but their number rapidly diminished. Sago appeared through the bloom and probably affected the food production, as the vegetation became very heavy by the last part of the fry-collection season.

Fingerlings were fairly even in size and were not fat.

Pond No. 6. The slope of the pond bottom is too steep. The pond is located in the center of the pond section, but seepage is moderate. Emergent vegetation is confined to scattered plants missed by the hand spray, and power-spray applications of 2,4-D weed killer eliminated

these plants.

The first application of fertilizer produced a good bloom, and this held until vegetation (pondweed, chara, and sago) attained a heavy growth (May 1). Daphnia production was very good.

First collection--Although small, fingerlings were in good condition.

Second collection--Fingerlings were of uniform size and in good condition. There was very little cannibalism. A water bloom appeared and was evident for 6 weeks after the second filling of the pond with water.

Pond No. 8. This pond is well built, except for a shallow area in the northwest corner and a low dyke that separates the pond from a slough on the east side. Emergent vegetation has been eliminated. Seepage from the pond is moderate.

Fertilization produced only moderate water bloom at times prior to first draining, and vegetation (pondweed and naias) was not too heavy during this period. The vegetation killed at the first draining produced a good bloom that lasted until 7 days before the second draining, at which time heavy beds of vegetation showed at the top of the water. Very little bloom and considerable algae appeared between the second and third drainings. Vegetation was moderate to heavy during the last period.

A 100- by 200-foot block near the kettle was treated with sodium arsenite (by power spray). Vegetation had dropped and partly deteriorated at draining.

First collection--Cannibalism had started. Fingerlings were fairly even in size but not fat. No food remained in the pond at this time. Evidently the pond was stocked with about 100,000 fry.

Second collection--Although considerable cannibalism had developed, fingerlings were fat.

Third collection--Fingerlings were even in size and in good condition.

Pond No. 9. Except for shallow areas in the northwest and southwest corners, Pond No. 9 is well constructed. It is bordered by the supply raceway on the west, and there is very little seepage from the pond. Emergent vegetation is confined to shallow areas in the corners.

Fertilization produced a good water bloom, and a good bloom continued to show until 3 weeks before the last draining. Daphnia were very plentiful until within 2 weeks of the first draining, when they disappeared. Vegetation (mostly sago) was heavy during both periods.

Sodium arsenite, applied with a power spray to a 150- by 100-foot area at the kettle, showed a good vegetation kill 60 days after treatment.

First collection--Fingerlings were in good condition but not fat. Cannibalism had developed to a moderate extent.

Second collection--Fingerlings were small and even in size, showing very little evidence of cannibalism. Two weeks before the last collection, large numbers of ducks started working the ponds. As the last fingerlings taken from this pond were small and even in size, it is evident that the ducks greatly reduced the percentage of recovery. Cold weather during the draining period made the fingerlings easy prey for the ducks.

Pond No. 10. This well-constructed pond in the center of the pond section loses an excessive amount of water by seepage. There is no emergent vegetation.

Fertilization produced a water bloom for 7 days in the first period, and a bloom was noted for 7 days after the first kill of vegetation. Vegetation (sago and chara) was abundant during the first period, light during the second period, and heavy in the deep part of the pond during the last period.

Sodium arsenite, applied with a power spray to 6,000 square feet around the kettle, had little effect upon vegetation. This probably was due to excessive seepage.

First collection--Cannibalism was well developed. This pond probably had been stocked with about 125,000 fry. The fingerlings were healthy but not fat, and there was no food remaining in the pond. Aquatic insects were never abundant: probably they were caught soon after hatching.

Second collection--There was very little cannibalism, and the fish were in excellent condition. Great numbers of daphnia appeared when the bloom faded, although there was no food in the pond when it was drained.

Third collection--Fingerlings were very even in size, showing no signs of cannibalism. This was a good recovery.

Pond No. 11. This uncompleted pond is located in the center of the pond section, and the seepage is excessive. When Pond No. 11 is full, one-third of the bottom is covered with 1 to 6 inches of water. The shallow area is covered with emergent vegetation (mostly spikerush).

At times, fertilization produced a fair bloom, but this quickly faded. For 2 weeks during the first part of the second period, the pond had a moderate bloom. Vegetation (pondweed) was moderate and spotty during the entire season.

Sodium arsenite was applied with a power spray to 7,000 square feet around the kettle. A good kill resulted. Algae had covered vegetation.

First collection--There was considerable cannibalism. The fish were uneven in size but in fair condition. A very small amount of food remained in the pond when it was drained. Obviously, more than 100,000 fry had been placed in this pond.

Second collection--Cannibalism had started. The fish were in good condition, and recovery was good.

Third collection--No cannibalism was apparent. Fish were small and even in size. Recovery was poor, probably because of large numbers of ducks that worked the pond 3 weeks before the draining. Cold weather during the draining period made it easier for the ducks to take fish.

Pond No. 15. This uncompleted pond borders on the overflow ditch on the west and south sides. The west and south dykes are low, and the bottom is very uneven. The large shallow area on the west side is covered with emergent vegetation (spikerush, bulrush, and smartweed).

Fertilization provided a good water bloom through most of the season. Vegetation (pondweed and sago) was very heavy during the first period and moderate during the last period.

Sodium arsenite, applied with a power spray to a 100- by 200-foot block at the kettle, effected a good kill in 60 days.

First collection--Fingerlings showed only moderate cannibalism, although they were not fat. This pond had evidently been stocked with more than 200,000 fry. Daphnia and related insects were abundant until the last 2 weeks of the period.

Second collection--Cannibalism was moderate. The fish were fat and fairly even in size. The low percentage of recovery reflected ideal conditions for predators along the drain ditch. Also, this pond was host to a large number of ducks 3 weeks before the draining.

Pond No. 17. Pond No. 17 has a shallow area along the north and east banks. It borders along the highway on the south, and seepage is excessive. Emergent vegetation (spikerush) appears in the shallow area (approximately one-sixth of the pond area).

Heavy fertilization failed to produce a water bloom at any time. Vegetation (chara) was thick and heavy in deep water, spotty in the remainder of the pond.

First collection--Cannibalism was well developed. Fingerlings were small and thin, although healthy. (These fish were used to restock a number of our ponds. When placed in a fertile pond, these fish appeared to get a good growth.) At an early date, we realized that we had overstocked this pond; we then introduced great numbers of daphnia to assist the fish in growing to a handling size. Evidently we had stocked the 1.33-acre pond with more than 100,000 fry--and approximately one-sixth of the pond was unproductive.

Second collection--Cannibalism was moderate. The fish were fairly even in size and in excellent condition. Algae were abundant for 3 weeks during this period. No food was noted when the pond was drained.

Third collection--Fish were in good condition and showed only a small amount of cannibalism. Predator birds had a field day in this pond.

Pond No. 22. This pond is well constructed, but the east side has never been finished and is shallow. Located on the south side of the highway, this is the only usable pond in this section. Seepage from the pond is so great that it is difficult to maintain a full pond. Emergent vegetation is scattered in the

northwest corner.

Fertilization failed to provide a water bloom at any time during the season. Vegetation was confined to a few small patches of chara during the first period and heavy growths of chara and pondweed during the last period.

First collection--It was a mistake to delay to a late date the stocking of this large pond, as even-sized fry were not available then. As a result of the stocking with uneven-sized fry and the failure to produce a water bloom or vegetation, cannibalism was well developed. Apparently we failed to produce a good culture of daphnia or related insects, as only a few were noted. Fingerlings were in good condition but were uneven in size.

Second collection--Fish were fairly even in size and in good condition. There was very little cannibalism.

BLUEGILL

The 1948 production of bluegills did not set a record at the station, as the only outstanding point was the method of fertilization. Because all applications were filled on an unfertilized basis, we knew that the production of bluegills could be reduced from the record achieved in 1947. Therefore, only four ponds (a total of 7.01 acres) were used entirely for bluegill production, and one additional pond (1.32 acres) was used during a part of the season.

No difficulty has been encountered in the production of bluegills at the Tishomingo station, provided that good food conditions have been maintained. We use traps to collect fingerlings needed for distribution in July and August. These traps can be moved as needed and are covered with 1/4-inch hardware cloth so the smaller fish can escape. The trapping of a bluegill pond is desirable because the procedure removes the larger fingerlings and reduces congestion, giving the smaller fingerlings a chance to grow. Our trapping operations were limited this season, owing to a large carry-over of bluegill fingerlings from the 1947 season. A larger size of fingerlings would have been harvested, however, if the ponds had been trapped properly.

Of particular interest in this year's production of bluegills, is the experiment conducted in Pond No. 16. It will be noted that this pond was heavily fertilized before June 30, and that only a light water bloom resulted from the use of fertilizers. It was apparent that a heavy crop of submerged vegetation was consuming the fertility, and it was decided to kill large areas of vegetation to provide fertility for the remainder of the season. Our first vegetation kill was almost too large, as we had to suspend trapping operations to avoid a loss of fish. We did produce an excellent water bloom, however, and we held this bloom for the remainder of the season with only one additional vegetation kill. Apparently the dead vegetation provided a large number of food organisms. Adults that had stopped spawning before the killing of the vegetation, started nesting activity soon after the vegetation dropped, and they continued to spawn until shortly before the pond was drained on October 13. Pond No. 16 produced 68 pounds more bluegills this season than during 1947. Ranging in size from very small fry to 3-inch fingerlings, all fish harvested from the pond this season were in excellent condition. The large production (table 2) was made in a pond that has excessive seepage and a shallow area that is below average in productivity because of the presence of emergent vegetation in small plots. It is believed that this experiment has proved that the controlled killing of submerged vegetation can be of value in the production of bluegills at this station.

Table 2 summarizes the information gathered and recorded for each of the bluegill ponds during the 1948 season. It will be noted that 1,239,969 bluegill fingerlings (weight, 1,996 pounds) were produced and distributed to applicants from the 8.33 acres of pond area, and--in addition--150,000 (estimate) fingerlings are being held for next season and a large number are being fed to adult bass.

The following paragraphs contain descriptions of individual ponds and information regarding the management of each.

TABLE 2.--Bluegill rearing ponds--1948

Pond No.	Acres	Depth	Water flow [1] g.p.m.	Fertilizer applied: Date	U.[2] lb.	S.[3] lb.	Cow lb.	Goat lb.	Weed control: Date	S.A.[4] p.p.m.	2,4-D 0.1%	Pond filled	Fish stocked: Date	Number	Size	Weight lb.	Fish removed: Date	Number	Size	Weight lb.	Production per acre: Number	Weight lb.
2	1.32	2-4 ft.	6	3/23	-	-	-	6,000	8/6	10	-	6/20	6/21	100	adult	-	11/5	130,000	1½	180	98,500	136
									8/18	-	(5/)	-	-	-	-	-	-	-	-	-	-	-
									8/23	10	-	-	-	-	-	-	-	-	-	-	-	-
									9/17	-	(5/)	(Early production shown in table 1.)										
									9/29	12	-	-	-	-	-	-	-	-	-	-	-	-
3	1.72	2-4 ft.	8	3/25-4/30	-	-	2,000	2,000	6/30	12	-	(1947)	(1947)	90	adult	-	4/22	51,905	2	192	-	-
				5/3-18	98	86	-	2,000	8/23	10	-	4/30	5/3	136	adult	-	9/1-3	156,480	1½-2	323	91,000[6]	188[6]
				6/7-29	98	86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	1.69	2-4 ft.	15	3/25-4/30	-	-	2,000	2,000	6/30	12	-	(1947)	(1947)	90	adult	-	4/25	100,000	2	384	-	-
				5/3-17	90	84	-	-	8/23	10	-	5/1	5/3	134	adult	-	11/23	105,000	1½	185	62,100[6]	109[6]
				6/7-29	90	84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	1.63	-	8	4/6-29	92	82	4,000	-	9/17	-	(5/)	4/7	4/7	80	adult	-	7/7	15,000	1½	25	-	-
				5/17-6/29	138	123	-	-	-	-	-	8/9	8/11	60	adult	-	8/4	141,000	1½	243	95,700	164
				9/13	40	41	-	-	-	-	-	-	12/20	50,000	1	-	(Second crop being held for 1949 distribution.)					
16	1.97	6 in. - 5 ft.	26	3/26-4/29	112	98	12,000	-	6/30	10	-	4/6	4/7	116	adult	-	7/7	7,200	-	12	-	-
				5/17	56	49	-	-	8/18	-	(5/)	-	-	-	-	-	10/13	652,200	1-1½	576	334,700	298
				6/7-29	112	98	-	-	8/23	10	-	-	-	-	-	-	-	-	-	-	-	-

[1] Water flow necessary to maintain water level.
[2] Uramon, 42% nitrogen.
[3] Superphosphate, 20%.
[4] Sodium arsenite. Information on treatment shown under pond description. (See Fishery Leaflet 10.)
[5] 2,4-D weed killer applied to spikerush in water solution (power spray), apparently good kill. (See Fishery Leaflet 217.)
[6] Figured on 1948 production only.

Pond No. 2. This well-constructed pond borders on the raceway on the north. There is only a small amount of emergent vegetation at the edges of the pond.

Efforts to fertilize this pond with a vegetation kill after the bass had been removed, failed, as a vegetation kill was not made with arsenite treatments. Considerable fertility resulted from the vegetation kill made when the pond was drained before the introduction of adult bluegills.

First collection--This is shown on the chart for bass production.

Second collection--Bluegill spawners had been held in a crowded condition before the pond was stocked, and they did not spawn until late. (Many of these spawners were very small adults.) Bluegill fingerlings were small and in good condition.

Pond No. 3. This well-constructed pond borders on the supply raceway on the north. It contains very little emergent vegetation.

Pond No. 3 was used to hold bluegill fingerlings from the 1947 season to April 22, 1948.

Fertilization was discontinued on June 29, and vegetation kill provided food for the remainder of the season. Vegetation (pondweed and naias) was heavy all season in untreated areas. No water bloom appeared until after the first vegetation kill, but there was a fair bloom during the remainder of the season.

On June 30, sodium arsenite was applied with hand shakers to three strips (100 by 15 feet) leading from the corners to kettle. A moderate kill was effected. Arsenite, applied with the power spray on August 23 to a 100-foot triangle at the kettle, provided an excellent kill.

First collection--This represented 1947 production.

Second collection--Bluegill fingerlings were fat, and those of the early hatches were large. Late hatches were noticeable and nesting activity was seen at the time of draining, indicating that food was abundant.

Pond No. 7. Located in the center of the pond section, this well-constructed pond has moderate seepage. Very little emergent vegetation appears in this pond.

Fertilization was provided by the vegetation kill after June 29. Water bloom was light before July 1 and moderate to good during the remainder of the season. Vegetation (pondweed and chara) was entirely killed and it then disappeared; untreated vegetation was affected and deteriorating at time of draining.

On June 30, sodium arsenite was applied with hand shakers to three strips (100 by 15 feet) leading from the corners to the kettle. A moderate kill was effected. Arsenite, applied with a power spray on August 23 to a 100-foot triangle at the kettle, provided an excellent kill.

First collection--This represented 1947 production.

Second collection--Fingerlings were fat, ranging from 1/2 to 2 inches in size and indicating that food conditions were good until late fall. Many fingerlings were lost during the draining operation and 2 weeks earlier on account of a great number of ducks working the pond.

Pond No. 12. Although shallow on the west side (one-eighth of the pond area), Pond No. 12 is well constructed. This pond is located in the center of the pond section, but there is very little seepage. Emergent vegetation (spikerush) is confined to the shallow area on the west side.

Vegetation (pondweed and naias) was heavy throughout the season. The pond had a moderate water bloom early in the first period and a good bloom during the first half of the second period.

First collection--Fingerlings were fairly even in size and in good condition. Adults had quit nesting during the last part of the period, and very few late hatches were noted.

The pond was restocked with the same adults used in the first period. Nesting activity was noted within 2 weeks after stocking, and a good hatch of fry was noted within another 2 weeks. Later observations showed several sizes of fry and small fingerlings in all parts of the pond. On December 20, 50,000 No. 1 bluegills were added to those already in the pond. It is estimated that 150,000 bluegill fingerlings are in the pond at this time. These fish will be held in

the pond until next season.

Pond No. 16. This pond has a shallow area (one-fourth of pond area) in the northeast corner. The pond borders on the drain ditch on the southeast, and seepage is excessive. Emergent vegetation is confined to small plots in the shallow area.

At the start of the season, it was decided to try an experiment in the fertilization of this pond. The pond was fertilized heavily between March 26 and June 29, and fertilization was provided during the remainder of the season by killing the vegetation with sodium arsenite. Plant growth (pondweed, chara, and sago) was heavy during the first 3 months, and only a light water bloom resulted from the use of fertilizers. Apparently the plant growth prevented a water bloom. An excellent bloom resulted from the first vegetation kill, and a good bloom continued to show in the pond during the remainder of the season. Oxygen was near the danger point after the first vegetation kill, but no loss of fish resulted except in traps that we were using at that time.

On June 30, sodium arsenite was applied with hand shakers to a 15-foot strip about the edge of the pond. Arsenite, applied with a power spray on August 23 to a 50-by 100-foot block northwest of the kettle, also gave a good kill. All vegetation was either dead or dying when we drained the pond.

The size of fingerlings ranged from 1 to 3 inches, and we noted a number of small fry. The good collection and heavy poundage indicated that an abundance of food had been available throughout the period.

SUMMARY

The recording of all available information on our 1948 production has already been of value in the following respects:

1. Errors in stocking and fertilizing individual ponds have been noted, and in the future an attempt can be made to correct these errors.
2. The multiple draining of bass rearing ponds and the grading of fingerlings, greatly increase the production of this species at the Tishomingo station.
3. Sodium arsenite has proved to be of value in making vegetation kills for refertilization of ponds handicapped by excessive seepage.
4. The close observation of each pond and its characteristics contributed to our knowledge of pondfish culture.

COMMENTS

Fisheries Biological Station,
West Hill, P.O., S. Malabar,
India. June 6th, 1949.

To
The Editor,
PROGRESSIVE FISH-CULTURIST,
Fish and Wildlife Service,
Washington, D. C.

Sir,

I have read the article on 'Bangos culture in the Philippines' by W. F. Carbine in Oct. '48 issue of THE PROGRESSIVE FISH-CULTURIST with considerable interest.

Carbine in this article states that 'the adults, which may reach a length of 5 ft. seldom enter shallow water except during the spawning season, at which time some of them are caught in nets and fish traps' and there is an apparent contradiction subsequently when he mentions that they 'must return to the ocean to spawn.' Herre and Mendoza (1929) report that the adult fish is rarely caught and 'it rarely approaches land or enters shallow water except during March, April and

May' and that 'it seems to spawn in quiet shallow sandy bays.' Adam et al. (1932) also suggest that they spawn from March to June or July off shallow sandy coasts, but give an indication that conditions in the open sea are favourable for reproductive purposes. Herre and Mendoza (1929) have not seen the eggs of Chanos after spawning and they suggest that they are of demersal type, whereas Adam et al. consider the eggs to be of floating type. Delsman (1926) had recorded a female, 1.2 metre long, having 5,700,000 eggs: he had not succeeded in collecting fertilized eggs of Chanos, except perhaps one on 24th Sept. 1921, which he believed was that of Chanos. He had also expressed the difficulty in finding the spawners nor the spawning grounds of Chanos. There have been very few records of Chanos with well developed gonads having been caught.

In South Indian Coasts, the fingerlings of Chanos are utilised to a fairly large extent for cultivation in freshwaters. The fry and fingerlings are available in large numbers in the shallow regions off Pamban and Tuticorin in the Gulf of Manaar, in the backwaters near Madras in April and May. So far I have not come across a single ripe individual in any of these areas, though young ones ranging from 12-15 mm. appear in large numbers. One female Chanos, measuring 48 inches and caught on 12-3-41 at a distance of about 15 miles showed the presence of a fairly developed ovary which was in the IVth stage of development. Four female specimens caught on 12th, 18th and 20th March 1948, at a distance of 10-15 miles from the shore in the Gulf of Manaar, showed that the ovaries were in the Vth stage of development. There were only a few individuals caught during fishing operations. These facts indicate that it is likely that the adult fish spawn at a fairly good distance away from the shore but not very far; the conditions of current and drift perhaps bring the larvae towards the shore. The breeding of Chanos still remains a mystery. Even though fishery biologists in the Indian and Pacific areas are attempting to unravel this mystery, any information on this by the game fishermen and field naturalists would be of special interest. I have been continuing my efforts to find out this phase of the problem and I will be pleased to know of any record of ripe specimens of Chanos by the scientists, naturalists and game fishermen.

Yours faithfully

K. Chidambaram.

In the article in question (PROGRESSIVE FISH-CULTURIST 10 (4): 187-197), I stated (page 188, first paragraph) that the bangos "seldom enter shallow water [of the ocean] except during the spawning season." In the second paragraph, I continued: "Bangos fry and fingerlings often enter fresh-water rivers, and a few individuals may find their way into lakes. These fish may grow to a large size in fresh water but never reach sexual maturity there and must return to the ocean to spawn." I see no contradiction here.

So very little work has been done on the spawning habits of the bangos that until several years ago most workers believed that the spawning season lasted only several months. This was due mainly to the fact that very few people had tried to collect bangos fry during the entire year in various sections of the Orient. It is now known that spawning must occur during all months of the year because newly hatched fry can be found during every month in certain localities in the Philippines.

In June 1948, I was fortunate enough to see the eggs of a nearly ripe female. This fish was captured in a trap by a fisherman who lived near the town of Legaspi in southern Luzon. The eggs in this fish were loose in the ovaries, dark yellow in color, and opaque.

--W. F. Carbine.

MONTANA FISH-DISTRIBUTION TANK

A. G. Stubblefield
Montana Department of Fish and Game
Helena, Montana

Lorin Lefevre
Great Falls, Montana

and

Rex Smart
Montana Department of Fish and Game
Helena, Montana

Much has been written about fish-distribution tanks, and many different types have been tried with varying degrees of success. In the last analysis, three factors apparently govern the degree of success of a tank used for distribution of live fish. These factors are aeration, cooling, and filtering of the water. During the past two seasons, a tank designed and used in the State of Montana has demonstrated a most effective treatment of these factors.

The Montana fish-distribution tank is the product of study and experimentation by the three authors. The senior author designed the tank, Lefevre designed (and patented) the aeration unit, and Smart worked out the aeration drive unit. Each of these men had a hand in adapting the various units to their specific use in the finished product.

It is generally conceded that the best type of aeration is based upon the introduction of fresh air into the water. In other tanks fresh air has been introduced with some success by means of a circulating pump and a venturi valve: the only drawback has been that the pump breaks up the particles of refuse matter in the water, causing the water to foam and making it necessary to use a filter. The Montana fish-distribution tank does not require a circulating pump, as the water is not pumped at all. Instead, in the Montana tank the water is circulated and constantly changed by means of a hollow rotating propeller operated in the center of the tank. Fresh air is brought into this impeller intake through a pipe to the propeller air tube and then diffused through the water by means of veins at the heel or along the edges of the propeller blades. This constant flow of fresh air is distributed by centrifugal force to all parts of the tank through the movement of the water. As the water is not pumped but instead is slowly circulated, a filter is not necessary.

The cooling is effected by the passage of air--a constant circulation being provided by means of a suction fan mounted under the rear of the platform--through pipes placed in the center channel. These

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See also:

Copeland, T. H.
1947. Fish distribution units. Prog. Fish-Cult. 9 (4): 193-202.

Stoddard, J. V.
1948. Refrigerated live-trout distribution tank. Prog. Fish-Cult. 10 (2): 91-94.

It should be noted that these drawings are reproduced through the courtesy of Mr. Lorin Lefevre, who has secured patent rights.--The EDITORS.

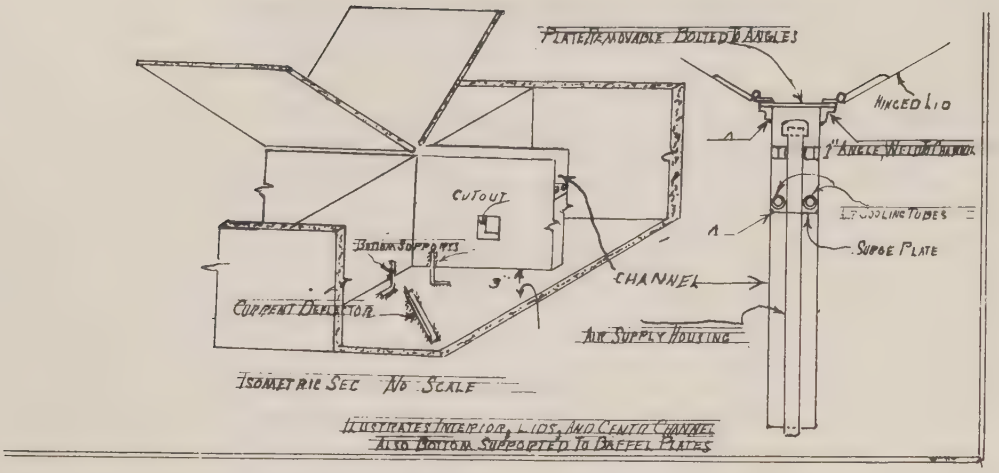
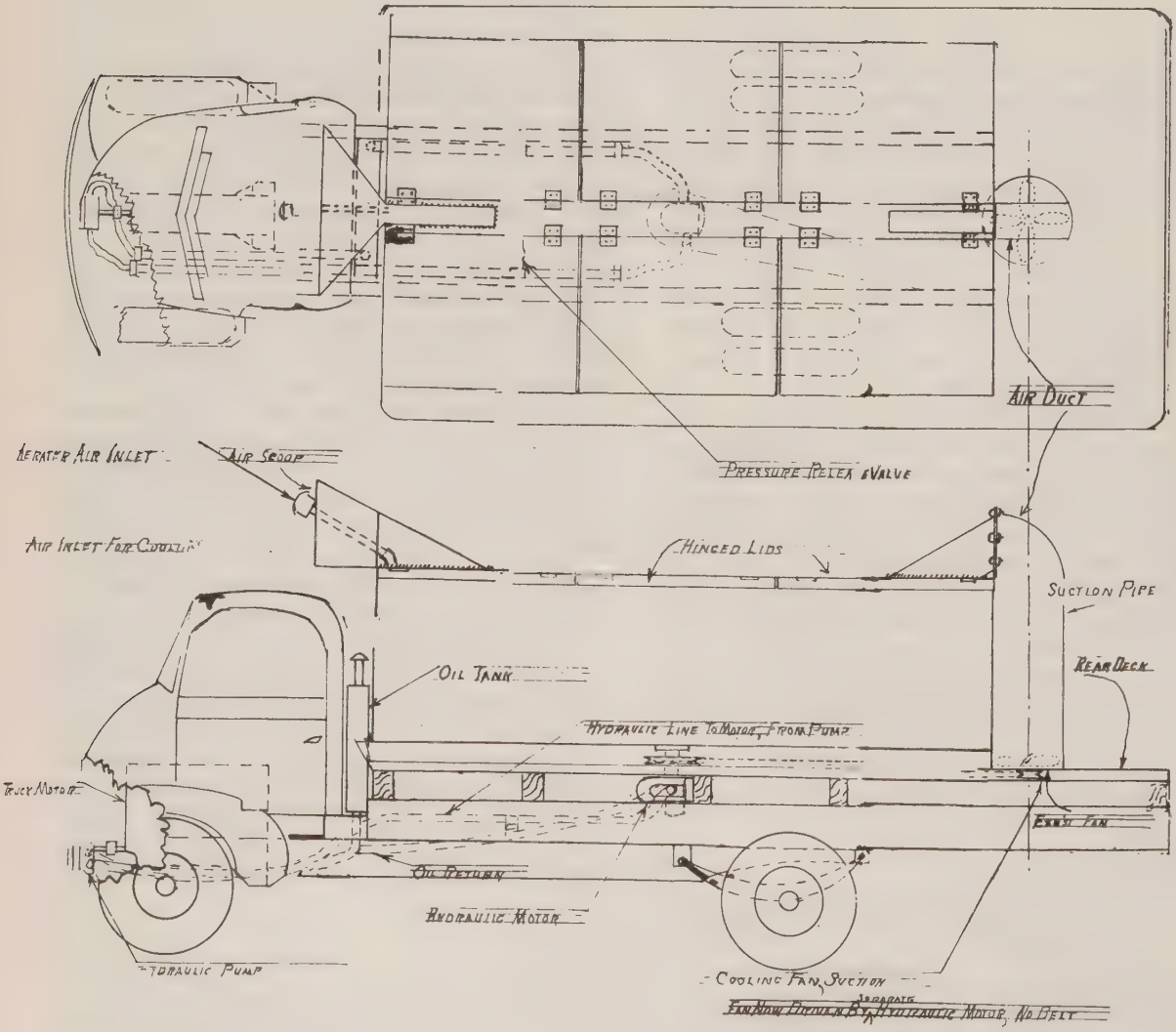
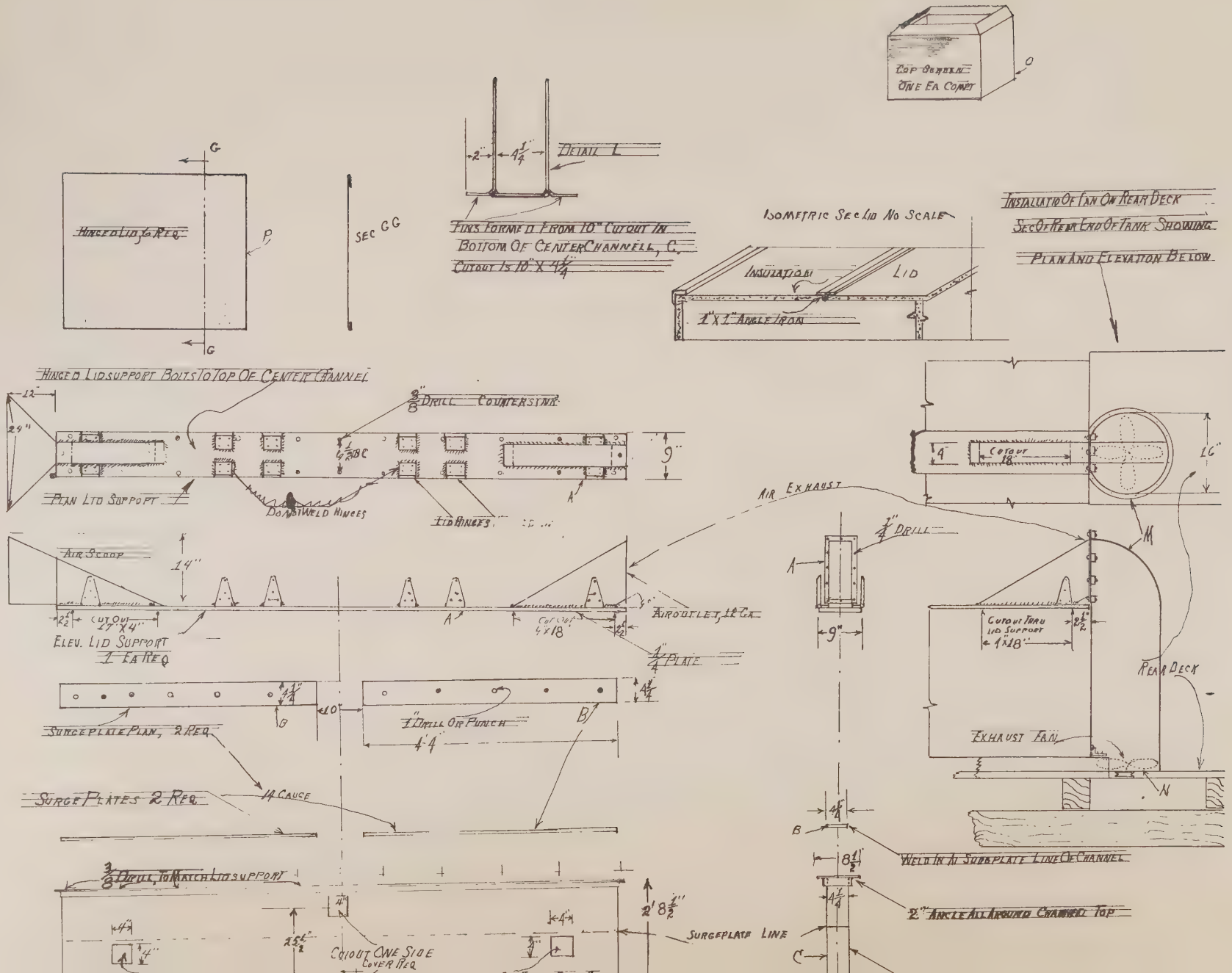
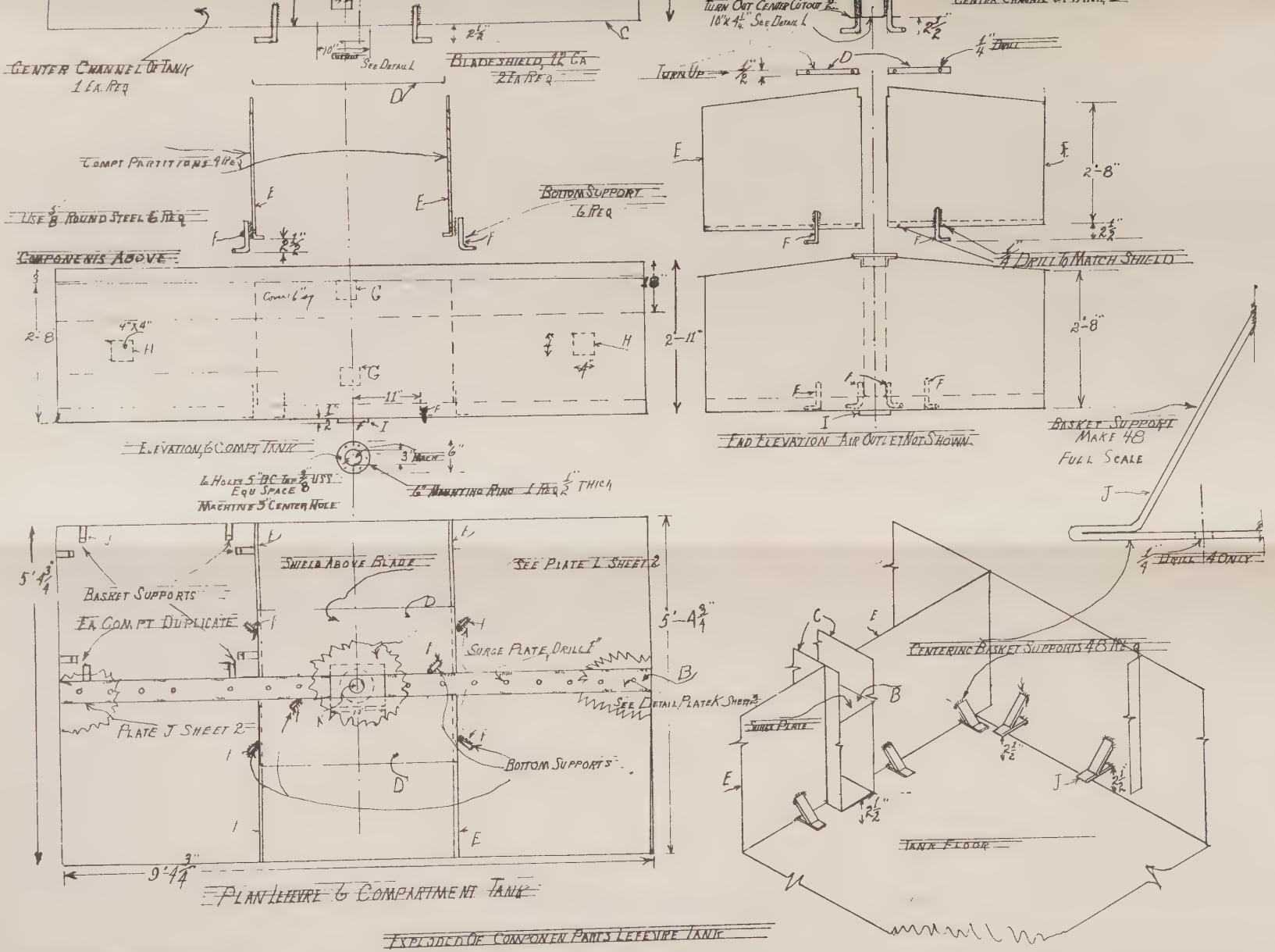


Plate Removable Bolted To Angles
Hinged Lid
1" Angle Welded To Lid
Cut Out
1" Cooling Tubes
Baffle Supports
Surge Plate
Channel
Current Deflector
Air Supply Housing
Isometric Sec No Scale
Illustrates Interior, Lids, And Center Channel
Also Bottom Supported To Baffel Plates


Air Duct
Aerator Air Inlet
Air Scoop
Pressure Relief Valve
Air Inlet For Cooling
Hinged Lids
Suction Pipe
Oil Tank
Rear Deck
Hydraulic Line To Motor, From Pump
Truck Motor
Exhaust Fan
Oil Return
Hydraulic Motor
Hydraulic Pump
Cooling Fan Suction
Fan Now Driven By Hydraulic Motor, No Belt


Top Bending One Ea Comt
Detail L
Fins Formed From 10" Cutout In Bottom Of Center Channell, C. Cutout Is 10" X 4 1/4"
Isometric See Lid No Scale
Insulation
Lid
1"X1" Angle Iron
Installation Of Fan On Rear Deck
Sec Of Rear End Of Tank Showing
Plan And Elevation Below
Hinge Loc 3 Req
Sec GG
Hinged Lid Support Bolts To Top Of Center Channel
2" Drill Countersink
Plan Lid Support
Double Weld Hinges
Lid Hinges
Air Scoop
Elev. Lid Support 1 Ea Req
Cut Out 27 X 4"
Air Outlet, 12 Ga
1/4" Plate
Surge Plate Plan, 2 Req
1" Drill Or Punch
Surge Plates 2 Req
14 Gauge
3/8" Drill, To Match Lid Support
Cutout One Side Cover Req
Surgeplate Line
Air Exhaust
1" Drill
Cutout 18"
Cutout Thru Lid Support 1"x18"
Rear Deck
Exhaust Fan
Weld In At Surgeplate Line Of Channel
2" Angle All Around Channel Top



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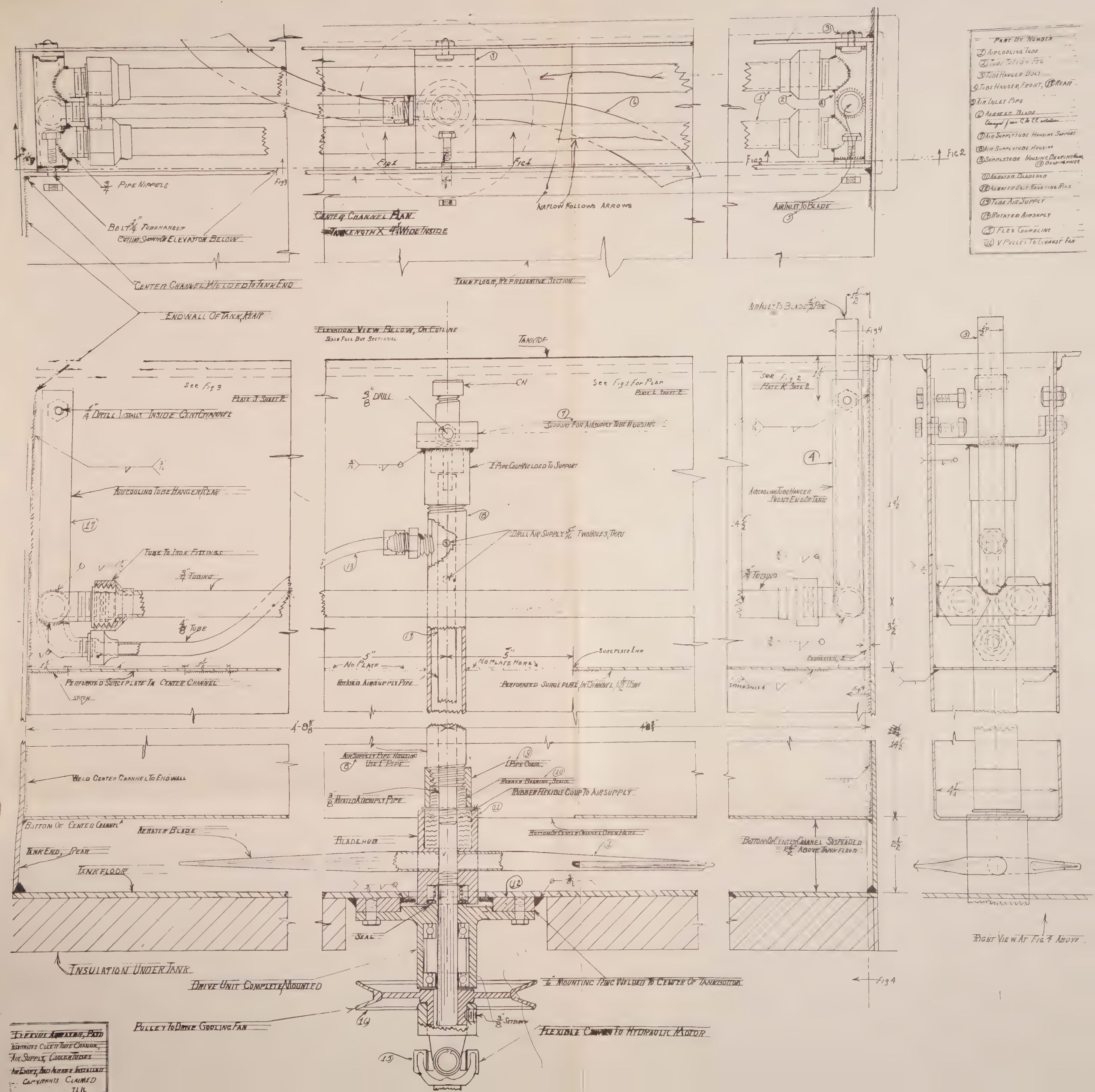
PART BY NUMBER
(1) AIR COOLING TUBE
(2) TUBE TO IRON FTG
(3) TUBE HANGER BOLT
(4) TUBE HANGER, FRONT, (17) REAR
(5) AIR INLET PIPE
(6) AERATOR BLADE
(7) AIR SUPPLY TUBE HOUSING SUPPORT
(8) AIR SUPPLY TUBE HOUSING
(9) SUPPLY TUBE HOUSING BEARING HOUSING (10) BEARING LOWER
(11) AERATOR BLADE HUB
(12) AERATOR UNIT HOUSING MAC
(13) TUBE AIR SUPPLY
(14) ROTATED AIR SUPPLY
(15) FLEX COUPELINE
(16) V PULLEY TO EXHAUST FAN
Fig 1
Fig 2
Fig 3
Fig 4
FIG 2
3/4 PIPE NIPPELS
BOLT 1/4" TUBE HANGER
OUTLINE SHOWN IN ELEVATION BELOW
CENTER CHANNEL WELDED TO TANK END
ENDWALL OF TANK, REAR
CENTER CHANNEL PLAN
TANK LENGTH X 4' WIDE INSIDE
AIRFLOW FOLLOWS ARROWS
AIR INLET TO BLADE
TANK FLOOR, REPRESENTIVE SECTION
AIR INLET TO BLADE 1/2" PIPE
ELEVATION VIEW BELOW, ON CUTLINE
SCALE FULL BUT SECTIONAL
TANK TOP
See Fig 3
PLATE 3 SHEET 2
1/4" DRILL INSTALLS INSIDE CENT CHANNEL
AIRCOOLING TUBE HANGER REAR
TUBE TO IRON FITTINGS
3/4" TUBING
3/8" TUBE
PERFORATED SURGE PLATE IN CENTER CHANNEL
STITCH
See Fig 1 for Plan
PLATE 1 SHEET 2
3/8" DRILL
SUPPORT FOR AIRSUPPLY TUBE HOUSING
1" PIPE COUP WELDED TO SUPPORT
DRILL AIR SUPPLY 5/16" TWO HOLES, THRU
5" NO PLATE
5" NO PLATE HERE
SURGE PLATE END
ROTATED AIRSUPPLY PIPE
PERFORATED SURGE PLATE IN CHANNEL 1/8" DOWN
See Fig 2 PLATE K SHEET 2
AIRCOOLING TUBE HANGER FRONT END OF TANK
3/4" TUBING
COUPELLEN
STITCH SPACE 4
AIR SUPPLY PIPE HOUSING USE 1" PIPE
1" PIPE COUP
RUBBER BEARING, STATIC
RUBBER FLEXIBLE COUP TO AIR SUPPLY
3/8" ROTATED AIRSUPPLY PIPE
BOTTOM OF CENTER CHANNEL OPEN HERE
BLADE HUB
SEAL
BOTTOM OF CENTER CHANNEL SUSPENDED 2 1/2" ABOVE TANK FLOOR
RIGHT VIEW AT FIG 7 ABOVE
WELD CENTER CHANNEL TO ENDWALL
BOTTOM OF CENTER CHANNEL
AERATOR BLADE
TANK END, REAR
TANK FLOOR
INSULATION UNDER TANK
DRIVE UNIT COMPLETELY MOUNTED
PULLEY TO DRIVE COOLING FAN
3/8" SETSCREW
FLEXIBLE COUP TO HYDRAULIC MOTOR
1/2" MOUNTING PINS WELDED TO CENTER OF TANK BOTTOM
4-8 3/8"
4-8 3/8"
14 1/2
4 1/4
2 1/2
3 1/2
1 1/2
4 1/2

EXECUTIVE AERATOR, PATD
ILLUSTRATES COLLER TUBE CHANNEL,
AIR SUPPLY, COOLER TUBES
AIR ENTRY, AND AERATOR INSTALLED
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TLK

pipes are wrapped with canvas, and the splashing of the water keeps the canvas wet. The water is cooled by the evaporation that results when air is passed through the wet-canvas-wrapped pipes to the blades. Of course, as is shown in the drawing, this tank is so thoroughly insulated that outside temperatures do not affect it too much if the lids are kept closed. Heavy loads of fish have been hauled long distances in the hottest weather without the use of ice, with a loss of no more than 4 degrees of temperature in the course of any one trip.

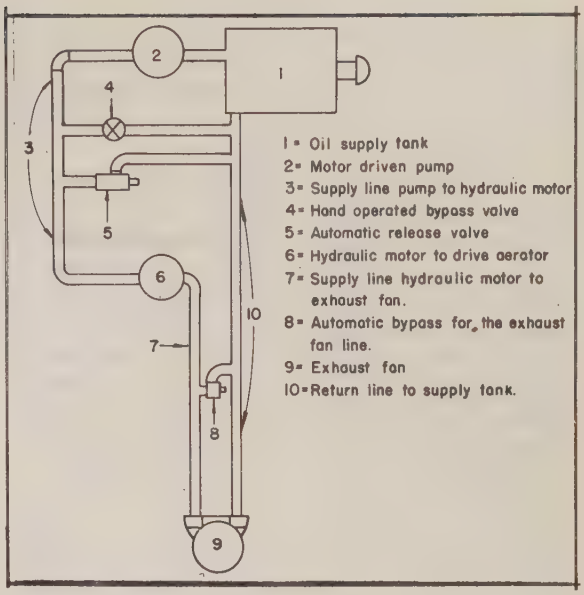
On a tank now under construction an air scoop is mounted, providing greater inlet to the center channel so that more air will be picked up and driven into the center channel when the truck is in motion. This will insure a stronger draft than is available with the present suction fan (mounted on the back of the truck) and will effect even greater efficiency in the cooling system.

The aerating unit is driven by a hydraulic motor--which, in turn, is driven by a pump directly off the truck motor. The pump forces oil through the hydraulic motor, the oil flowing to a tank back of the cab and then returning to the pump. This unit insures constant aeration of the water as long as the truck motor is running. A throw-off device permits the driver of the truck to stop the aerator when it is not needed.

A circulating pump of the old conventional type is mounted on the back of the truck as standby equipment. This pump can be operated by a gas engine if there is any trouble with the aeration, but so far there has been no necessity for its use.

The exhaust fan on the present tank is V-belt driven from the hydraulic motor driving the aerator. On the tank now being built, however, the exhaust fan will be driven by a small hydraulic motor coupled in parallel with the motor driving the aerator. (See the sketch of the complete hydraulic circuit.)

An automatic pressure-relief valve in the circuit of the pump and hydraulic unit insures nearly constant speed of the aerating unit regardless of the speed of the truck engine. In addition, should the automatic device not function correctly, a hand-operated by-pass valve in the cab can be used by the driver to regulate the amount of oil passing through the hydraulic motor.



A tacometer mounted in the cab enables the driver to know at all times the speed of his aerating unit. Also, the water temperature in the tank is indicated on a thermometer mounted in the cab.

This tank is placed on a 1½-ton cab-over-engine Chevrolet truck. The cab-over-engine type has been used because the tank can be set farther ahead, permitting better balance without requiring use of the long wheel-base truck.

This Montana unit usually carries fish 3 inches or longer, and the load of fish of this size has usually been 100 pounds to the compartment or 600 pounds of fish to the tank--or, using 400 gallons of water, 1½ pounds of fish per gallon of water. In one load, as many as 1,000 pounds of adult fish have been hauled in the customary 400 gallons of water. This indicates that the aeration is nearly perfect and that the water can be aerated almost without regard to the amount of fish in the tank.

Test of Aeration Device

Severe, full testing of the aeration device on the Montana fish-distribution tank has disclosed that chlorine-treated water, such as most cities have, may be

so cleared of chemicals harmful to marine life that the water will be perfectly safe for the highest forms of fish life, such as trout, which are very susceptible to the effects of chlorine.

A recent test involved two lots of trout which ranged from 2 to 8 inches in length. The first lot was placed in a small glass tank that had city tap water running into it constantly. All these fish exhibited exceeding distress after 1 hour, and all were dead after 2½ hours. The second lot was placed in city water which had been aerated until it showed no chemical reaction indicating chlorine. The aeration device was operated constantly while these fish were held in the tank. These fish were held in the tank for 50 hours, after which they were returned--apparently in excellent condition and with no losses--to the hatchery.

This test was made to determine whether fish life could be maintained without the usual losses in water which had been heavily chlorinated. As the fish used in this experiment were trout (highly susceptible to chlorine damage), there can be no doubt that treated water can be made perfectly safe for the maintenance of marine life.

Shooting a stream of separate droplets at aquatic and air-dwelling prey, the Siamese Archer has been known to score almost 100 percent in accuracy at distances up to 4 feet. As the Archer's eyes are always under water when the fish shoots--and the eyes apparently have no specialized features--one of the greatest mysteries is how this fish compensates for refraction and judges distance. Moreover, when the fish shoots, it claps down its gill covers to force water through its mouth and at the same time forces some water out at the rear: as this tends to move the Archer forward, that movement also must be allowed for in a well-directed shot.

The whale, our largest mammal, requires in its diet the euphasid shrimp, a very small animal known to whalers as krill. This small shrimp, in turn, lives upon the smaller members of the nannoplankton, chiefly diatoms less than 40 microns in diameter. In areas of the Antarctic where whales are abundant, the plankton includes a rich supply of small diatoms. Conversely, where the plankton is made up of larger prickly forms not suitable for the euphasid shrimp, whales are rare.

Molasses may be a favored bait to catch flies, but water has become the standard bait for the ring-necked pheasant over much of its range in California.

EXTENDED SURVEY

OF FISH CULTURE IN THE UNITED STATES

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U. S. Fish and Wildlife Service
Washington, D. C.

The growing popularity of fish for food and recreation has increased the need for better management of our fishing waters. As fish-culture has become recognized as one of the important tools of management, a questionnaire was forwarded in June 1948 to the various State fishery authorities for the purpose of determining the extent of fish-cultural activity in this country. Although admittedly incomplete, the data received during the summer and fall of 1948 were summarized in the January 1949 issue of THE PROGRESSIVE FISH-CULTURIST. These data provided at least a partial picture of present-day operations.

Since the appearance of that report, a few additional States have supplied information regarding the status of fish-culture within their borders. Because of the ever-increasing demands upon our fisheries, it has seemed desirable to revise the January statement to include the newly received material.

It should be noted that although 46 States have now responded to the questionnaire, some of these States have not supplied complete information on all points: a State that reported its production in detail may have failed to provide a complete picture of the fishing pressure or of the fish-food problem. The tables here included are therefore based upon data reported by a varying number of States.

The list of hatcheries presented in table 1 may be regarded as an amendment to the first table in the January article. As neither the number nor the location of Federal hatcheries in these three States has changed, only the State hatcheries have been named.

Forty-four States have now submitted a break-down of the fish production under their direction. Table 2 presents the detailed distribution data submitted by 7 late-reporting States and the totals of the 37 States that reported earlier on this part of the questionnaire.

Table 3 is a summary of the distribution from the hatcheries of 44 States and the Fish and Wildlife Service.

In connection with future production programs, fishery workers may wish to compare the numbers of fry, fingerling, or 6-inch largemouth black bass (or Atlantic salmon, or grayling, or any other species) that have been distributed. For convenience, the January summary of the fish distribution by species has been revised to show the distribution from the hatcheries of 44 States and the Fish and Wildlife Service.

Complete information regarding the expenditures involved in fish-cultural work is naturally essential to evaluation of the current situation and should serve as the basis for estimates of future activity in various sections of the country. As 6 States reported their expenditures too late for inclusion in the January statement, table 5 has been prepared to show their costs and the totals previously published for 37 States and the Fish and Wildlife Service.

It is obvious that fishing pressure, research, and farm ponds also have direct influence upon the modern fishery problem. Listed in the earlier report, 38 States drew upon their records to supply information about these factors. Since the appearance of the January article, however, data submitted by six more States have

TABLE 1.--Hatcheries reported by 3 States

Hatchery and location	Hatchery and location
Colorado	Minnesota (continued)
Buena Vista - Buena Vista	Big Stone Rearing Pond - Ortonville
Cedaredge - Cedaredge	Burgan's Lake Rearing Pond - Alexandria
Denver - Henderson	Cove Bay Rearing Pond - Isle
Durango - Durango	Crystal Springs Trout Ponds - Altura
Estes Park - Estes Park	Cut Foot Sioux Pike - Deer River
Fort Collins - Bennevue	Detroit Lakes Hatchery and Ponds - Detroit Lakes
Glenwood Springs - Glenwood Springs	French River Trout - French River
La Jara - La Jara	Glenwood Hatchery and Ponds - Glenwood
Monument Lake - Weston	Glenwood Rearing Ponds - Glenwood
Pitkin - Pitkin	Hinckley Rearing Ponds - Hinckley
Rye - Rye	Hutchinson Rearing Pond - Hutchinson
Walden - Walden	I. W. L. A. Rearing Pond - Minneapolis
Wray - Wray	Jenkins Pike - Pine River
---	Lake of the Woods Pike - Baudette
Retaining ponds	Lanesboro Trout Hatchery and Ponds - Lanesboro
Bellaire - Buford	Mille Lacs Rearing Pond - near Garrison
Coal Dale - Coal Dale	Mission Lake Rearing Pond - Merrifield
Crystal River - Carbondale	Park Rapids Hatchery and Ponds - Park Rapids
North Fork Big Thompson - Drake	Ranier Pike - Ranier
Rio Grande Project - Monte Vista	St. Croix Rearing Pond - Hinckley
Rocky Mountain Trout Farm Consolidated Denver - Henderson	St. Paul Hatchery and Ponds - St. Paul
---	St. Peter - St. Peter
Trout rearing ponds	Straight Lake Rearing Pond - Osage
Bellaire - Buford	Sturgeon's Rearing Pond - Side Lake
Chalk Cliff	Tower Pike - Tower
Chipeta	Warren Lake Ponds - Windom
Crystal River - Carbondale	Waskish Pike - Waskish
Dolores	
Finger Rock	Nevada
Monument Lake - Weston	Verdi Fish - Verdi
North Fork Big Thompson - Drake	---
Poudre River	County hatcheries
Rio Grande Project - Monte Vista	Elko County Fish - Ruby Valley
	Washoe County Fish - Idlewild Park, Reno
Minnesota	
Agate Lake Rearing Pond - Brainerd	
Bemidji Rearing Pond - Bemidji	
Bemidji Pike - Bemidji	

made possible a more nearly accurate picture of the situation. Table 6 lists the newly reported data and the totals shown in the January statement.

The January summary covered personnel engaged in fish-cultural work in 39 States and the Fish and Wildlife Service. Table 7 lists personnel employed by six additional States and the totals previously reported.

TABLE 2.--Distribution of fish from hatcheries of 44 States

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Colorado	Loch Leven	456,860	196,185	347,431	1,000,476
1/1/48 to 1/1/49	Brook Trout	418,041	8,420	440	426,901
	Native Trout	1,359,291	0	29,847	1,389,138
	Rainbow Trout	219,997	37,318	1,238,931	1,496,246
	Bluegill Sunfish	-	129,064	-	129,064
	Largemouth Bass	-	37,667	-	37,667
	Crappie	-	51,811	-	51,811
	Yellow Perch	-	19,000	-	19,000
Kansas	Bass	-	150,000	20,000	170,000
1948	Channel Cat	-	180,000	12,000	192,000
	Crappie	-	170,000	-	170,000
	Bluegill	-	30,000	-	30,000
Minnesota	Walleyed Pike	182,010,016	2,795,758	-	184,805,774
1947	Northern Pike	9,805,000	75,412	-	9,880,412
	Largemouth Bass	-	581,784	-	581,784
	Smallmouth Bass	-	39,909	-	39,909
	Silver Bass	-	-	60	60
	Crappie	-	145,248	-	145,248
	Sunfish	-	957,506	-	957,506
	Stream Trout	-	554,600	339,442	894,042
	Lake Trout	705,000	81,000	-	786,000
	Herring	742,000	-	-	742,000
	Whitefish	920,000	-	-	920,000
	Bullhead	-	-	896,024	896,024
	Catfish	-	3,623	-	3,623
	Minnow	-	-	2,633,925	2,633,925
	Perch	-	-	90,930	90,930
	Sucker	23,790,350	-	94,356	23,884,706

(Continued)

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Nevada	Rainbow Trout	-	1,266,500	-	1,266,500
1/1/48 to 1/1/49	Cutthroat Trout	-	997,900	-	997,900
South Dakota	Loch Leven Trout	-	436,800	400	437,200
7/1/46 to 7/1/47	Rainbow Trout	-	370,250	1,005	371,255
	Brook Trout	-	120,500	-	120,500
	Walleyed Pike	11,475,000	-	-	11,475,000
	Perch	13,700,000	-	-	13,700,000
	Northern Pike	9,200,000	2,300	-	9,202,300
	Bluegill	-	20,000	8,500	28,500
	Bullhead	-	-	383,500	383,500
	Crappie	-	-	13,000	13,000
Utah	Rainbow	2,729,930	1,371,684	4,039,472	8,141,086
7/1/46 to 6/30/48	Brown	4,596,258	1,117,834	116,738	5,830,830
	Native	14,756,380	20,400	6	14,776,786
	Eastern Brook	1,738,080	1,755,596	9,870	3,503,546
	Grayling	2,601,296	-	-	2,601,296
	Mackinaw	-	235,400	-	235,400
	Catfish	-	-	5,200	5,200
Vermont	Brook Trout	1,011,295	824,454	207,380	2,043,129
1948	Brown Trout	145,340	30,000	3,378	178,718
	Rainbow Trout	-	107,300	33,118	140,418
	Lake Trout	-	294,000	9,540	303,540
	L. L. Salmon	-	-	15,465	15,465
Totals		282,380,134	15,215,223	10,549,958	308,145,315
Previously reported totals		1,368,520,170	154,964,405	22,122,080	1,545,606,655
Grand Totals		1,650,900,304	170,179,628	32,672,038	1,853,751,970

TABLE 3.--Summary of fish distribution from hatcheries of 44 States and the Fish and Wildlife Service

Source	Fry	Fingerling	6 inches and more	Total
Colorado	2,454,189	479,465	1,616,649	4,550,303
Kansas	-	530,000	32,000	562,000
Minnesota	217,972,366	5,234,840	4,054,737	227,261,943
Nevada	-	2,264,400	-	2,264,400
South Dakota	34,375,000	949,850	406,405	35,731,255
Utah	26,421,944	4,500,914	4,171,286	35,094,144
Vermont	1,156,635	1,255,754	268,881	2,681,270
Previously reported from 37 States	1,368,520,170	154,964,405	22,122,080	1,545,606,655
from Fish and Wild-life Service	1,218,255,687	92,845,513	1,758,917	1,312,860,117
Totals	2,869,155,991	263,025,141	34,430,955	3,166,612,087

TABLE 4.--Summary of fish distribution, by species, from hatcheries of the Fish and Wildlife Service and of 44 States

Species	Fry	Fingerling	6 inches and more	Total
Bass,				
Largemouth Black	2,986,786	25,592,074	343,024	28,921,884
Rock	-	381,237	321	381,558
Smallmouth Black	1,531,000	1,603,913	18,490	3,153,403
Spotted Black	-	4,305	-	4,305
Striped	7,756,000	-	-	7,756,000
Warmouth	-	154,693	20	154,713
White	-	-	60	60
Yellow	-	453	-	453
Unclassified	858,805	2,091,084	195,895	3,145,784
Buffalo	-	220,100	500	220,600
Bullhead,				
Black	-	-	3,235	3,235
Brown	800	1,089,533	1,983,620	3,073,953
Carp	-	167,500	108,066	275,566
Catfish,				
Channel	130,750	2,440,205	71,266	2,642,221
Yellow	-	4,185	-	4,185
Unclassified	-	549,494	180,052	729,546
Cisco	5,400,000	-	-	5,400,000
Crappie,				
Black	-	135,900	15,635	151,535
Unclassified	2,750	3,154,310	92,020	3,249,080
Flounder	1,136,737,865	-	-	1,136,737,865
Goldfish	-	35	270	305
Grayling	5,095,296	43,138	30,016	5,168,450
Herring	742,000	-	-	742,000
Lobster	1,164,300	-	-	1,164,300
Minnow,				
Bluntnose and Fathead	-	2,455,000	-	2,455,000
Fathead	-	12,000	-	12,000
Top	-	30,000	-	30,000
Unclassified	-	201,733	2,664,575	2,866,308
Muskellunge	10,418,696	227,293	14,512	10,660,501
Perch,				
White	1,950,000	-	-	1,950,000
Yellow	157,712,500	442,187	45,324	158,200,011
Unclassified	13,700,000	84,987	94,342	13,879,329
Pickerel	-	-	14,674	14,674
Pike,				
Great Northern	30,222,674	81,630	5,034	30,309,338
Wall-eyed	596,394,933	3,944,901	2,341	600,342,175
Unclassified	-	-	23	23
Pike-Perch,				
Yellow	79,560,000	-	650	79,560,650
Unclassified	485,414,597	58,264	19,001	485,491,862

(continued)

TABLE 4. (Continued)

Species	Fry	Fingerling	6 inches and more	Total
Salmon,				
Atlantic	-	94,225	74,617	168,842
Chum	8,456,082	-	-	8,456,082
King	33,523,726	43,785,660	53,047	77,362,433
Kokanee	-	457,800	-	457,800
Red	4,794,300	4,716,298	79,812	9,590,410
Sebago	2,000,000	1,003,508	422,824	3,426,332
Silver	1,173,177	9,820,774	181,800	11,175,751
Shad	14,311,000	1,500	-	14,312,500
Shiner,				
Golden	-	42,740	-	42,740
Unclassified	-	5,000	-	5,000
Sucker,				
Red Horse	-	-	11	11
Unclassified	23,790,350	18,807	97,901	23,907,058
Sunfish,				
Bluegill	154,790	41,844,541	132,571	42,131,902
Green	-	454,845	-	454,845
Red-ear	-	1,176,209	1,099	1,177,308
Yellow-belly	-	6,500	19	6,519
Unclassified	2,500,000	10,678,258	247,687	13,425,945
Tadpoles	10,000	554,720	-	564,720
Terrapin	7,000	-	-	7,000
Trout,				
Brown	6,857,837	9,017,189	2,581,861	18,456,887
Cutthroat	28,506,969	15,258,735	1,237,409	45,003,113
Eastern Brook	9,016,755	19,398,355	4,601,992	33,017,102
Golden	3,856	-	-	3,856
Lake	2,855,900	2,474,012	93,372	5,423,284
Rainbow	18,140,968	43,217,860	14,056,482	75,415,310
Silver	43,162,194	53,768	-	43,215,962
Steelhead	1,069,335	3,622,169	105,766	4,797,270
Sunapee	-	-	5,957	5,957
Unclassified	-	4,787,641	3,902,228	8,689,869
Whitefish	131,042,000	-	-	131,042,000
Miscellaneous	-	5,363,873	651,534	6,015,407
Totals	2,869,155,991	263,025,141	34,430,955	3,166,612,087

TABLE 5.--Costs reported by 43 States and the Fish and Wildlife Service

Source	Replacement cost of hatcheries (estimate)	Operations (Upkeep, new building, etc.)[1]	Payroll[1]	Fish food[1]	
				Pounds	Cost
Colorado	$ 5,000,000.00	$ 612,264.81	$ 160,376.19	1,000,000	$ 84,620.82
Kansas	250,000.00	12,000.00	7,800.00	16,000	1,120.00
Minnesota	1,700,000.00	251,099.39[2]	116,526.65[2]	297,683	20,790.81
Nevada	200,000.00	29,200.00	12,240.00	21,600	2,592.00
South Dakota	-	-	23,636.50	-	5,798.39
Utah	342,565.00	638,019.57	168,289.56	4,140,500	165,620.46
Previously reported from 37 States	27,635,760.00	8,873,852.85	3,650,869.08	22,233,949	1,770,317.79
from Fish and Wildlife Service	12,383,900.00	1,621,905.00	952,495.00	2,040,943	142,878.00
Totals	$47,512,225.00	$12,038,341.62	$5,092,232.98	29,750,675	$2,193,738.27

[1] Unless otherwise indicated, data are for period listed in table 2.
[2] 1946-1947.

TABLE 6.--Fishing pressure, research, and farm ponds reported by 44 States and the Fish and Wildlife Service

Source	Fishing pressure[1]					Research[1]		Farm ponds[1]
	Resident licenses		Nonresident licenses		Unlicensed (estimate)	Number of personnel	Total expenditure	
	Number	Fees	Number	Fees				
Colorado	232,337	$ 358,281.00	44,466	$ 187,030.50	25,000	12	$ 40,000.00	-
Kansas	222,000	332,959.50	5,086	11,606.30	300,000	3	5,000.00	6,000
Minnesota	624,382	689,698.60	187,939	612,963.75	250,000	24[2]	44,668.32[2]	10
Nevada	22,331	55,827.50	11,288	45,152.00	3,108	1	5,500.00	0
South Dakota	81,623	81,623.00	17,524	33,979.00	64,136	-	-	-
Utah	170,740	362,644.40	9,745	33,124.00	10,000	5	3,500.00	75
Previously reported from 38 States	8,626,558	$13,432,793.58	924,300	$2,832,399.92	3,420,161	254	$1,082,420.68	271,321
Fish and Wildlife Service						70	391,028.00	
Totals	9,979,971	$15,313,827.58	1,200,348	$3,756,255.47	4,072,405	369	$1,572,117.00	277,406

[1] Unless otherwise indicated, data are for period listed in table 2.
[2] 1946-1947.

TABLE 7.--Personnel reported by 45 States and the Fish and Wildlife Service

Source	Administrator[1]	Fish-culturist[1]	Laborer[1]
Colorado	2	90	-
Kansas	-	1	3
Minnesota	17[2]	12[2]	50[2]
Nevada	2	2	1
South Dakota	1	4	3
Utah	2	12	16
Previously reported from 39 States	121	622	709
from Fish and Wildlife Service	12	334	46
Totals	157	1,077	828

[1] [2] Unless otherwise indicated, data are for period listed in table 2. 1946-1947.

NYLON NETS FOR FISH COLLECTORS

Two home-made nylon nets, each with a heavily leaded bottom line and an upper brail cord of cotton instead of corks, are still serviceable after a year of hard use in Oklahoma waters. George A. Moore, professor of zoology at Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma, reports that the mesh never separates and, as nylon does not soak up water, the nets dry rapidly and resist decay.

Skillfully handled, small (3- or 4-foot) fine-mesh nylon seines enable fish collectors to make qualitative surveys of waters that present a great variety of habitat. Using his small nylon nets to supplement larger seines in his work with the Oklahoma Cooperative Wildlife Research Unit, Moore has taken not only the larger forms such as the black basses but also Microperca and Elassoma, mud-dwellers like lamprey larvae, and the crepuscular or semicrepuscular forms such as Schilbeodes and percids that prefer the riffles.

Since their introduction into various waters in northern California in 1941, kokanee--also known as little red fish or silver trout--have gradually become more popular among anglers.

A SIMPLE METHOD OF MOUNTING SCALES

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Several media have been used at one time or another in mounting fish scales for age and growth studies. Dry scales or scales mounted in a drop of water seem to show essential features more clearly and in better contrast than do scales mounted in most of the other media. The principal disadvantages of temporary dry or wet mounts are the time involved in making the mounts and the difficulties encountered in locating the same scales for future examinations. The method described in this article has little that is new but has proved very satisfactory in scale and growth studies on several species of Centrarchidae, Percidae, and Serranidae. The mounts are permanent and easily stored.

Some scales may need to be cleaned by rubbing between the fingers or scrubbing with a small brush after soaking in water for a while, but most scales show the essential features without much cleaning. Two or three scales from a fish are mounted between two microscope slides, the ends of which are bound together with 1-inch squares of waterproof adhesive tape. (Because some brands of tape stretch excessively, it may be necessary to try several brands.) The serial number for the specimen or other pertinent data may be written directly on the tape binding.

Small thin scales are most easily examined with a microprojector while they are dry, and therefore they require no further treatment. The two slides bound together hold the scales flat. Thicker scales are usually more clearly projected when they are thoroughly wet. A whole series of slide mounts may be placed in a shallow pan and a quarter of an inch of hot distilled water added to the pan. Capillary action will immediately draw the water up around the scales, and the slides may then be removed from the pan. Hot water seems to soak the scales more rapidly than cold water, and distilled water is recommended to prevent the leaving of residual salts as the water dries. The thinner scales can be examined immediately after being wet, but thicker scales will often be covered with air bubbles, and the scale features will not be so sharp as after the scale has been soaked for a couple of hours. Within 2 hours even the thickest scales reach optimum condition for examination. Even after they have begun to dry, they will immediately regain optimum condition if they are moistened again.

When the body-scale relationship is to be determined, it is necessary to read all of the scales dry or wet, as the scales expand somewhat when thoroughly moistened. It might also be suggested that the scales be selected from a precisely prescribed part of the body, usually just above or below the lateral line and even with the insertion of the dorsal fin.

From the Iowa Cooperative Fisheries Research Unit, sponsored by the Industrial Science Research Institute of Iowa State College and the Iowa State Conservation Commission, with the cooperation of the U. S. Fish and Wildlife Service.

EFFECT OF ACID TREATMENT ON pH AND FISH

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High pH of the water in a small fishpond on my farm led me to try reducing the pH through the use of acid. This pond, located 4 miles north of Albuquerque, New Mexico, has a surface area of 1/3 acre, contains 1-1/4 acre-feet of water, and has a maximum depth of 9 feet. The pH of the water over a period of 3 months prior to treatment ranged from 8.3 to 9.7.

At 1:00 p.m. on May 24, 1947, the pH was 9.3 at the south end of the pond and 9.0 at the north end. Between 1:00 and 3:00 p.m., 200 pounds of commercial-grade sulphuric acid were distributed at various points in the pond. A minnow seine was dragged continuously through the water to distribute the acid while it was being applied. After the application of acid (3:45 p.m.), the pH was 6.3 at the north end and 6.2 at the south end.

On May 25 at 5:30 p.m., the pH was 6.6 at both ends of the pond.

After May 25 only one water sample was taken each day, resulting in the following readings:

May 26,	7:45 a.m.	-	pH = 6.6
May 27,	7:30 a.m.	-	pH = 7.0
May 28,	7:45 a.m.	-	pH = 7.1
May 29,	7:30 a.m.	-	pH = 8.1
May 30,	9:00 a.m.	-	pH = 8.6
June 2,	7:30 a.m.	-	pH = 8.9
June 25,	7:30 a.m.	-	pH = 9.3

Water samples were taken in clean glass jars to the Soil Conservation Service laboratory in Albuquerque, where the pH was measured with a Beckman pH meter using a glass electrode.

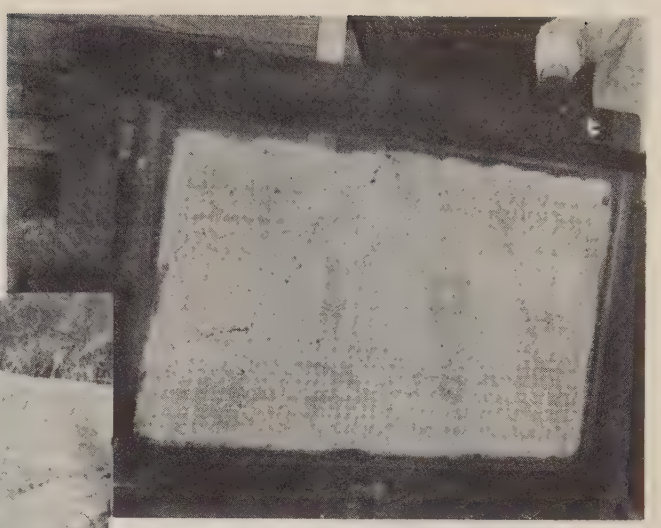
This series of readings demonstrates that within 9 days the pH had risen from 6.2-6.3 to 8.9 and that the effect of the acid was brief. During this 9-day period no irrigation flood water entered the pond.

At the time of treatment, the pond had a large population of various ages of largemouth black bass, bluegill, and channel catfish. During application of the acid eight small bluegills that entered areas of high acid concentration were killed, but no large fish of any species showed signs of distress. The day after treatment, more than 100 bluegills were taken on hook and line and many bluegills were active on their spawning beds--indications that the acid treatment did not disrupt the normal activities of the fish.

So far as I could detect, the acid had no adverse effect on insect larvae, tadpoles, or bullfrogs.

Although this note is based upon only one experiment, there is some indication that under the conditions existing in this pond the sudden change from alkaline to acid had no adverse effect on the fish, and that--because of its brief effect--the use of acid was impractical as a means of lowering the pH.

A "QUICK-CHANGE" SCREEN FOR FISH HATCHERY PONDS



(Illustrations courtesy of the authors)

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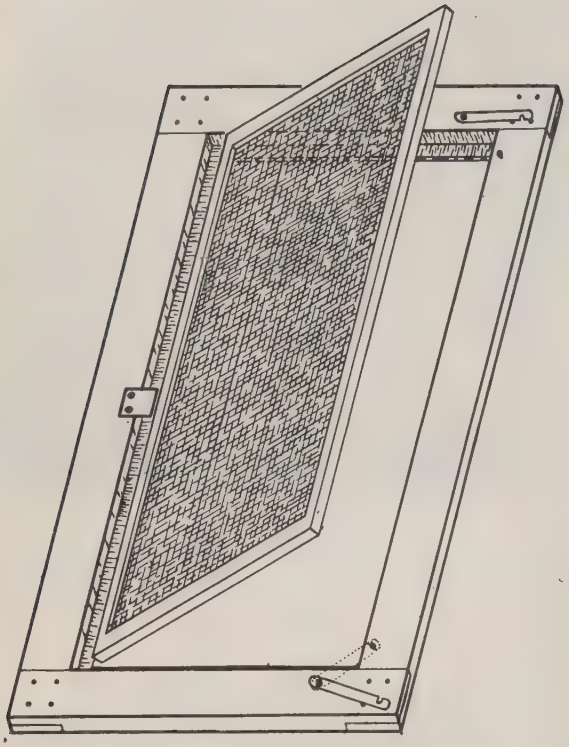
Michigan Department of Conservation
Grayling, Michigan

The screens in ponds at fish hatcheries must be removed from the bulkheads at various times during the year to clean the ponds, to make repairs, or to change the size of the mesh. In removing these screens, the entire frame is lifted out. If the screens are large and if many are to be changed, the task involves considerable time and labor. When the screens are replaced, the seat in the floor of the bulkhead must be thoroughly cleaned of gravel and debris in order to insure a snug fit that will prevent the escape of fish.

At the State Fish Hatchery in Grayling, Michigan, the screens ice-up heavily in winter and the frames freeze to the bulkheads. Also, at this station it is always necessary to clean the floor seat because the pond bottoms are composed of sand, gravel, and other debris introduced with the supply water, which comes directly from the East Branch of the Au Sable River. The senior author, having experienced these difficulties for a number of years, designed and put into use the screen described here. The idea is similar to that of using one frame for both screens and storm windows in homes.

The main frame is built of 2- by 4-inch lumber, fastened at each corner with four brass screws. On the side to face downstream, strips of wood (1-1/4 by 2-3/4 inches) are fastened far enough from the outer edge to permit the frame to slide easily into the keyway of the bulkhead; these strips extend inside the frame to make a flange 1-1/2 inches wide. On the upstream side of the frame, a plate 4 inches square made from 1/8-inch strap iron is fastened by brass screws to the middle of the bottom; this plate is set so that it projects above the 2- by 4-inch strips to make a flange 1/2-inch wide. The clips or bars that hold the screen in place at the top are 1/8-inch strap iron, 7 inches long and 1 inch wide. They are fastened in place by lag screws so they can easily be loosened or tightened if necessary. Screens of various-sized meshes are fastened to frames made of lumber (2-1/2 by 1-1/4 inches) and of



a size to fit into the larger frame with 1/4-inch clearance on all four sides. All wooden parts are heavily coated with creosote. (See sketch for details.)

Although the idea of using screens that fit into frames is not new, the writers feel that because these "quick-change" screens have proved to be very useful at this station, they might also be useful at other stations having similar problems. Once the frame is set into the keyway, the frame need not be removed except for repair or replacement; the screens can be removed in winter with little difficulty because they do not freeze in so tightly as the large frames, and an appreciable amount of time and labor can be saved when a number of the screens need to be changed. By actual timing, one man can remove a screen and replace it with another in less than 1 minute. The inexperienced worker can change these screens with ease, whereas it takes an experienced hand to reset the large frames so that they will be fish-tight. Another advantage in the use of this type of screen is the saving realized through the smaller screen needed.

Experimentation with this type of screen is not complete, although the one described here has proved very satisfactory. Further work is planned for refinements of the present screen, such as the use of aluminum angle bars as a frame for the screen.

The writers gratefully acknowledge the technical advice of Messrs. H. L. Peterson, A. B. Cook, and M. J. DeBoer, and the kind assistance of the hatchery crew.

Fertilization with nitrate and phosphate at intervals during the autumn, winter, and spring for several years resulted in a marked increase in phytoplankton within an 18-acre enclosed sea loch in Scotland. After 2 years the bottom fauna increased in spite of the larger fish population resulting from the introduction of small plaice and flounders. The rate of growth of the fish in this loch was three or four times greater than in the open sea. A much larger unenclosed loch gave similar results.

PUBLICATIONS

REPRINT

THE FISHERIES PICTURE

WITH SPECIAL REFERENCE TO THE TVA IMPOUNDMENTS

THE FISHERIES SITUATION ON TVA IMPOUNDMENTS (Part II)

Presented to Conservation Conference, U. S. Corps of Engineers at Cincinnati, Ohio, February 19, 1948.

R. W. Eschmeyer
Tennessee Valley Authority
Norris, Tennessee

At a time when it was becoming increasingly difficult to meet the fishing demand in most areas, TVA asked state fisheries authorities to discard the closed season on TVA waters as an experiment. We have shown little interest in size limits, and have stressed repeatedly that most fish of desirable size and species, in TVA waters, never sample an angler's lure. If anglers and fish conservationists are showing more than casual interest in the TVA fisheries investigation program, this, too, is understandable.

The fisheries picture on TVA impoundments can be reviewed only very briefly here. The discussion is limited to a few of the major observations. It should be understood that impoundments differ and that the findings on TVA waters do not necessarily apply elsewhere. Too, our information is limited to past and present fish conditions. We make no predictions as to what the fisheries picture will be like ten or fifty years from now.

TVA waters now include 26 reservoirs having an area of about 600,000 acres, and a shoreline of some 10,000 miles. Fisheries investigations have been conducted most extensively on two reservoirs--Norris, oldest TVA-built storage reservoir, and Wheeler, oldest TVA-built mainstream reservoir. These two waters serve as "test" reservoirs; information gathered there is applied to the others.

It should be stated that the two kinds of reservoirs differ greatly. The nine mainstream waters, impoundments of the Tennessee between Knoxville and Paducah, retain river characteristics; there is little if any oxygen and temperature stratification. On the other hand, storage waters more nearly resemble natural lakes in stratification. Navigation must be maintained on the former so there is only limited winter drawdown. Storage waters are drawn down many feet each winter for flood control. Investigations

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Reprinted from Wildlife in North Carolina 13 (3): 17-20. March 1949.
The first section of this article was reprinted in the July 1949 issue of the PROGRESSIVE FISH-CULTURIST.

show that fish conditions differ rather widely in the two types of water.

Here are a few pertinent observations:

Increase in Fishing. Among the early investigations was a study to note changes in fishing brought about by impoundment. This study suggests that fishing on the storage reservoirs increased 45- to 50-fold (not per cent) over fishing on the streams before the dams were built. On the mainstream reservoirs the increase was 10- to 15-fold. With year-round fishing the angling pressure has almost doubled, everywhere except in Alabama waters where year-round fishing for most species has been permitted since impoundment. This means that impoundment has increased fishing nearly a hundred-fold on storage waters, and perhaps 25-fold on mainstream waters outside of Alabama.

Extent of Angling. Fishermen counts show that Norris supported about 4 fishing trips per acre in 1944. The tailwaters (waters immediately below the dams) on the Tennessee supported an estimated 393,000 fishing trips in the 1947 fiscal year. Four mainstream reservoirs combined had an estimated average of 5 trips per acre in 1940, exclusive of fishing on tailwaters.

This information is admittedly too inadequate to permit a close estimate of total fishing, but reducing the numbers to 3 individual trips per acre on storage waters, and 2 on the mainstream, should provide a very conservative estimate. On this basis the 148,739 acres of storage water support about 450,000 individual trips annually, the tailwaters another 450,000 and the 447,450 acres of mainstream water about 890,000. The estimate of fishing on all TVA waters, admittedly rough but still conservative, is about 1-3/4 million individual trips per year.

In 1944 the catch on Norris averaged close to 13 pounds per acre. In the Guntersville Dam tailwater the catch during the 1947 fiscal year was 4.5 pounds per trip. On several mainstream waters the estimated take per trip in 1940 was as follows: Guntersville, 2.2 pounds; Wheeler, 2.8 pounds; Wilson, 2.6 pounds; and Pickwick, 2.3 pounds.

Estimated at 10 pounds yield per acre the storage waters yield 1-1/2 million pounds annually. At 4 pounds per trip, the tailwaters yield 1-3/4 million pounds. At 2 pounds per trip, the mainstream waters yield 1-3/4 million pounds. Again, these are rough estimates, but if they are in error, the error is on the conservative side. The total catch for all TVA waters probably exceeds the estimated 5 million pounds per year.

Trends in Fishing. Fishing appears to be improving in terms of average number of fish caught per trip. On seven waters (four storage, two mainstream, one tailwater) where a creel census has been taken for three successive springs, the catch from April 1 to May 15 was greatest the third season (1947) at three locations, the second season at one, and the first season at three. For all waters combined, fishing was definitely better in 1947 than in any previous year.

On Cherokee in early 1947, with an estimated three-fold increase in fishing over 1945, the number of fish caught per trip also increased almost three-fold.

All information on fishing to date suggests that angling has greatly increased on the Tennessee and its tributaries since these waters were impounded. There is still no evidence that they are becoming "biological deserts."

The Closed Season. The closed season has now been discontinued for four years on several reservoirs and for three years on most of the other TVA impoundments. It was discontinued (by the Tennessee Conservation Department) on Norris Reservoir as a result of certain findings: (1) Norris Reservoir was well supplied with bass and other game fish. (2) Only a small percentage of these very desirable fish was being harvested. (3) The sudden decline in fishing soon after the opening of the season coincided with a change in game-fish feeding (from 1-year-old shad and crappie to the very abundant young-of-the-year fish). (4) The depth distribution of fish, largely determined by water temperature, covered a wide range in the fall; the fish were not concentrated at any one depth. (5) In winter few game fish were active; those that were (sauger and walleye) could not be

readily caught, probably because the low temperature slowed up their digestive processes. (6) Even though the fishing season was open for two consecutive seasons when spawning was at its height, a good crop of young game fish nevertheless resulted.

In short, we found that most game fish were not taken, that adequate harvesting was not possible by summer, fall, and winter fishing alone, and that fishing during the spawning season did not prevent successful reproduction in this reservoir. We found out too, from growth studies, that these very fast-growing fish did not live as long as their slow-growing relatives in less suitable waters, or in northern waters where the growing season is shorter.

On all but two TVA waters the closed season was discontinued early in 1945; since then all have been open to year-round fishing. Some have interpreted this to mean that fishing is good "the year round." That, of course, is not so.

Extensive creel census studies made since the closed season was discontinued have revealed no general decline in fishing. Tagging studies still show that most fish are not caught even with year-round fishing. All evidence to date suggests that this change in regulation, which greatly increased the catch, and which is valued at several million dollars per year in added business generated (boats, motors, tackle, etc.), has no harmful effect on the fishery.

Extent of Harvesting. Numerous tagging studies have been made and all tell the same story--inadequate harvesting. Of 1,443 fish of various species tagged early in 1947, 120 had been reported recaptured by November 24. Of 1,000 adult crappie tagged in Wheeler Reservoir in 1946, 13 have been retaken; of a similar number tagged in 1947, 15 were reported retaken by November 15. To minimize injury, all tagging is done in winter and spring when the water is cool. Evidence collected in 1940 suggests that no appreciable mortality results from the tagging operations.

Spawning Success. In normal operation, the mainstream reservoirs are full and at constant level at spawning time; storage waters are rising slowly. Frequent population studies have revealed good reproduction of game fish in both types of reservoirs.

In 1947, with a heavy demand for electric power and with abnormally low rainfall, there was a slow decline in water level at spawning time on some storage waters. Even under these conditions there was good reproduction.

The Winter Drawdown. Though contrary to all expectation, the winter drawdown for flood control appears to be advantageous to game fish. It apparently does not interfere with their reproduction and survival. It does, however, interfere with the well-being of rough fish.

Because of the drawdown, the bottom feeders (carp, buffalo, and adult shad) have little food. Inquiries on Norris Reservoir for several years showed most carp in poor condition. Most of the females examined failed to spawn even though their eggs seemed to have developed normally.

The several permanent-level pools on TVA impoundments have provided poorer fishing than have the reservoirs proper. One such pool on Norris Reservoir, when examined, could support fish only in the upper fifteen feet because of stagnation. A 68-acre pond at the head of Chickamauga Reservoir contained about 19,000 pounds of fish two years after original impoundment. Nearly 18,000 pounds were rough fish; game and pan fish comprised only 1,235 pounds.

The winter drawdown apparently limits the abundance of rough fish (by limiting their food), without seriously injuring the game fish population.

The drawdown, of course, does interfere somewhat with boating. It certainly contributes nothing to the scenic beauty of the impoundments.

The Rough Fish Problem. There is no rough fish problem on TVA storage waters, presumably for the reasons just mentioned. Some rough fish are present but they are not abundant--and they are becoming less abundant with each year of impoundment.

These species are much more abundant on the mainstream reservoirs (where drawdown is limited to a few feet) but studies suggest that they are also decreasing here. The low transparency of the water

in mainstream reservoirs can probably be attributed to the bottom feeding of the rough fish. In general, these reservoirs are less clear than the storage waters.

Commercial Fishing. Commercial fishing is not included in the estimates above, or in the discussion to follow. This type of fishing is chiefly with snaglines for catfish and spoonbill, though there is also some netting and trotline fishing. It is limited almost entirely to the mainstream waters. Fish reported purchased by buyers during the 1947 fiscal year totalled 1,550,000 pounds and was valued at $298,000. These figures do not include sales by the fishermen direct to the consumer.

The Food Chain. Food studies on Norris indicate that the gizzard shad is the chief factor in the food chain--in fact, fishing in TVA storage waters would probably be poor if this species were not present. The major food chain is plankton--shad--game fish. This requires no coarse aquatic vegetation and does not call for constant water level. Insects are scarce in waters having extensive drawdown. Insect-eaters, such as the bluegill, grow slowly; fish-eaters grow rapidly.

Small bluegills are a very significant item in the food of young-of-the-year bass.

Since food items like insects, crayfish, and snails are scarce, adult fish must subsist on other fish (or plankton). For this reason some species are taken on plugs more often than might be expected. Norris Reservoir drum are taken extensively on these baits in the fall. Channel catfish are also taken on plugs. Even an occasional carp is caught on this type of bait.

Harvestability of Species. It is well known that brown trout are less easily harvested than brook trout, but the question of "harvestability" of warm-water fish has received little attention. According to the returns from tagging, walleye are much more difficult to harvest than largemouth bass. Population studies show a much higher percentage of smallmouth bass in the fish population than in the black bass catch. The largemouth bass and the black crappie are probably the most easily harvested of the game and pan fish on storage waters--the largemouth because it tends to be concentrated in shallow water in spring; the black crappie because it can be concentrated by use of fish shelters.

Vegetation. There is no aquatic vegetation in storage waters because of the drawdown. Its absence does not appear to limit the game fish population. Some aquatics are present in those mainstream reservoirs where the drawdown is limited to a very few feet.

Depth Distribution. Inquiries show that the fish tend to be distributed over a wide range in depth. Temperature appears to be the major contributing factor. On storage waters, species like the largemouth bass, which tend to be in shallow water in spring, may be distributed more or less evenly through the upper 50 or 70 feet in fall. Walleye have a wide distribution at all times. No fish distributed over a wide range of depth is easy to harvest.

On Wheeler Reservoir (mainstream) where temperatures are more uniform from top to bottom, the white crappie tend to be in the shallow backwaters in spring; in summer they appear to be most abundant at depths of about 15 feet.

Growth of Fishes. Growth of Norris Reservoir fish has been studied for the first 10 years of impoundment. There was a slight decline in growth after the first few years but the rate of growth has continued rapid. Largemouth bass reach legal size (10 inches) early in their second year; spotted bass grow to legal size in two full years; smallmouth bass are legal size in two and a fraction years. Although growth of game fish has not been studied extensively on waters other than Norris, it appears to be fairly rapid on most TVA impoundments.

Stocking. Most fisheries workers seem to agree that the benefits of stocking large bodies of water with warm-water fish are mostly, if not entirely, psychological. Our experience on TVA waters fails to prove otherwise. Even during the first year of impoundment large crops of young are produced naturally. The young fish produced by the brood stock

present in the original stream have few enemies the first year. Survival is exceptionally good. Though no careful study has been made of the first-year reproduction, unstocked waters apparently were as well supplied with fish as were those which had artificial stocking.

Stocking to introduce new species in several TVA storage reservoirs has been successful.

Trout Possibilities. Trout were naturally present in several of the impoundments and have been introduced in one or two others. But as yet there is no extensive trout fishery in any TVA reservoir.

Since completion of Fontana Dam, the water in the Little Tennessee River below that dam has become cold. Investigations now in progress suggest that this river, one of the bigger streams in the Tennessee Valley, has possibilities of becoming a trout stream.

The North Carolina Wildlife Resources Commission plans experimental stocking of lake trout in several TVA impoundments. We cannot say, at present, whether or not a trout fishery will develop, but some of the reservoirs (at higher elevations) have strata which seem well suited to trout insofar as oxygen and temperature are concerned.

Time of Harvesting. On Norris Reservoir fishing is best in spring--between the time the water warms to 60 degrees and the time young-of-the-year fish are about an inch long. Until the water temperature reaches 60 degrees the fish are too inactive to be taken readily on artificial bait. When the young reach a length of an inch or so, they provide a plentiful food supply for adult game fish. The lures offered by the angler just don't stand a chance.

GENERAL CONSIDERATIONS

We need hardly mention that our findings and observations differ considerably from what had been expected. The "biological deserts" have not developed yet. What the future holds is unpredictable. Be that as it may, we can certainly take a more optimistic view of fishing on impoundments than we once did.

Though I cannot comment on fishing possibilities of the numerous impoundments being built by the Corps of Engineers, I offer the following observations for consideration:

1. The fisheries aspects of impoundments should be regarded as having more than ordinary significance.
2. These waters may greatly improve general fishing conditions if they are managed partly for angling.
3. We still know too little about management on reservoirs. More fisheries research is obviously needed. It should be encouraged.
4. At present, erosion control is the most important fish management tool at our disposal. Eventually we will find the answers to most fish management problems. But if the reservoirs have filled with silt in the meantime, the information will be of no value.

Viewing the fisheries picture as a whole, therefore, erosion control should have first consideration, with fisheries investigation next in importance.

ABSTRACT

EFFECTS OF REMOVAL OF FINS UPON THE GROWTH AND SURVIVAL OF SPINY-RAYED FISHES. W. E. Ricker. Jour. Wild. Mgt. 13 (1): 29-40. (1949).--The removal of one or more fins from adult bluegill and redear sunfish (Lepomis macrochirus and L. microlophus) apparently caused no significant handicap to growth and survival. Experiments with

fingerling largemouth bass (Huro salmoides) indicated that such mutilation may have an important unfavorable effect upon survival and possibly a less striking effect upon rate of growth.

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